«Academic research and railways: lessons learnt»

Dr. Gabrio Caimi, SBB
Ambra Toletti, ETH Zurich

Zurich, 28 March 2018

Agenda

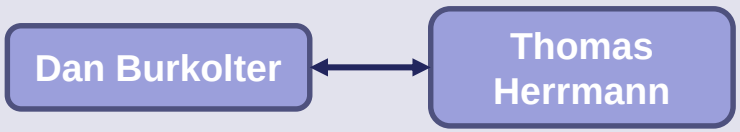
- Overview on formal collaboration ETH Zurich – SBB on timetabling and operations topics
- Focus on current PhD thesis of Ambra Toletti
- Lesson learnt from the collaboration and future challenges

18 years of formal collaboration between ETH Zurich and SBB: PhD theses

2000

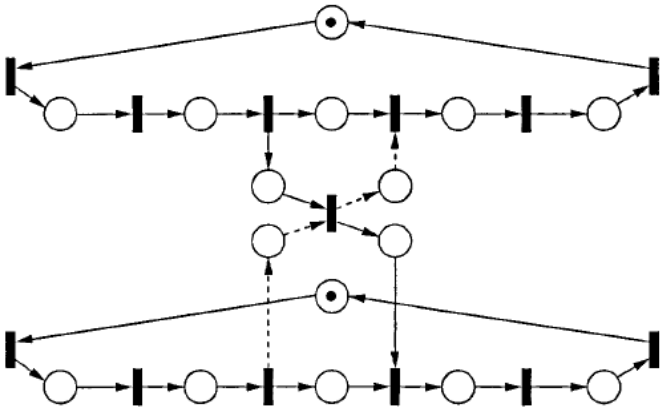
Institute of Operations Research

Prof. Hans-Jakob Lüthi

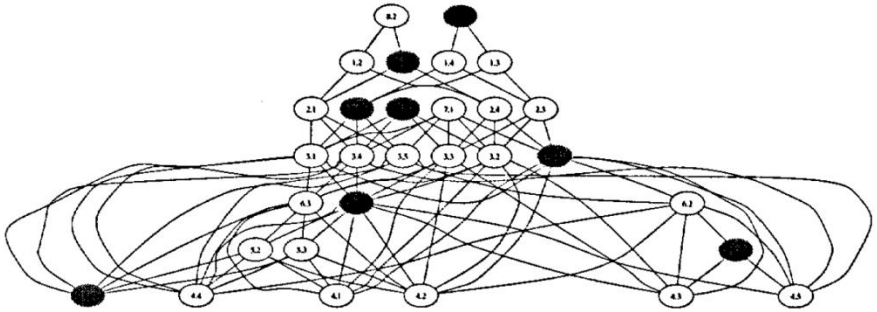


2000-2005: Dan Burkolter and Thomas Herrmann

- Capacity of Railways in Station Areas using Petri Nets, 2005



- Stability of Timetables and Train Routings through Station Regions, 2005



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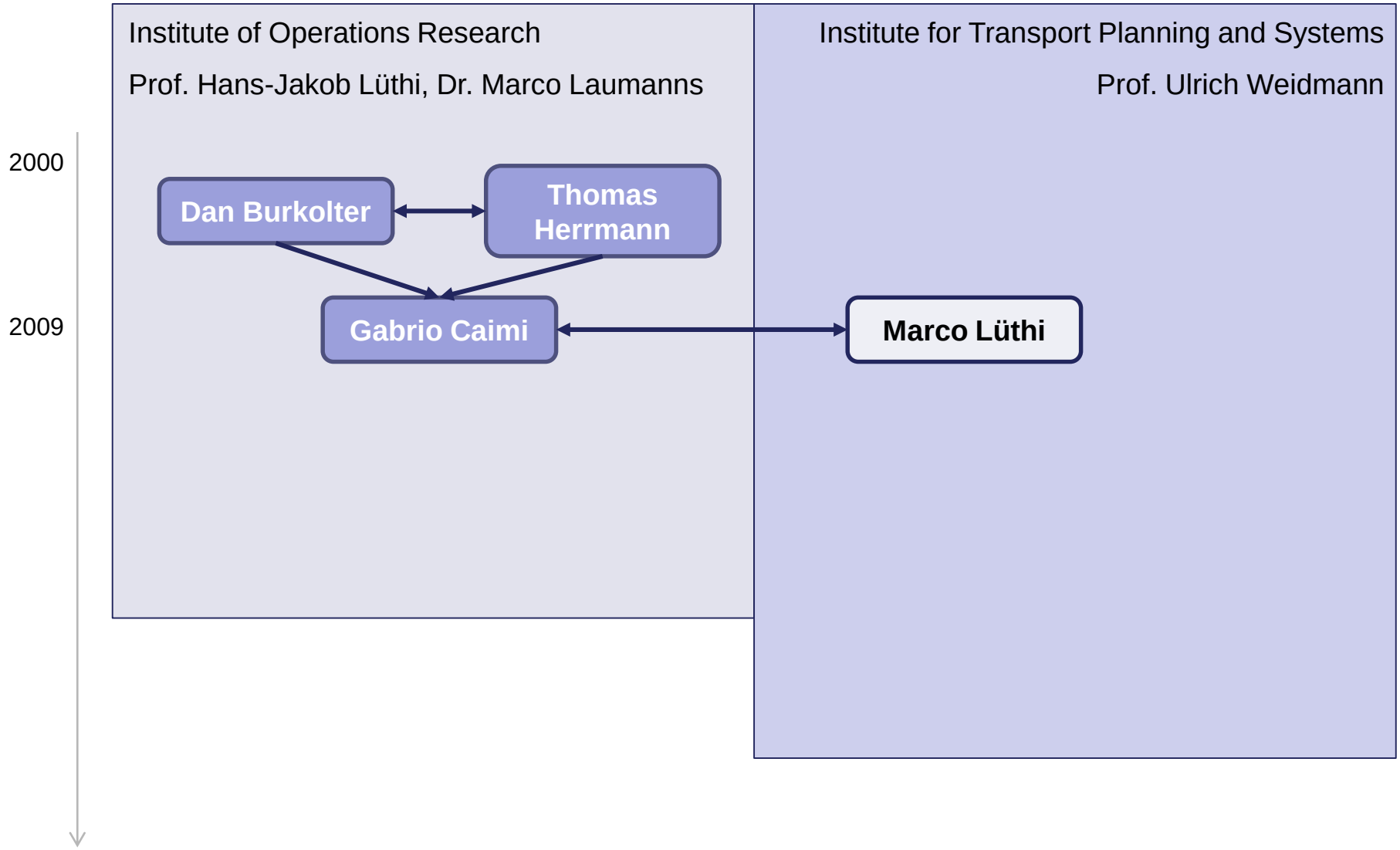
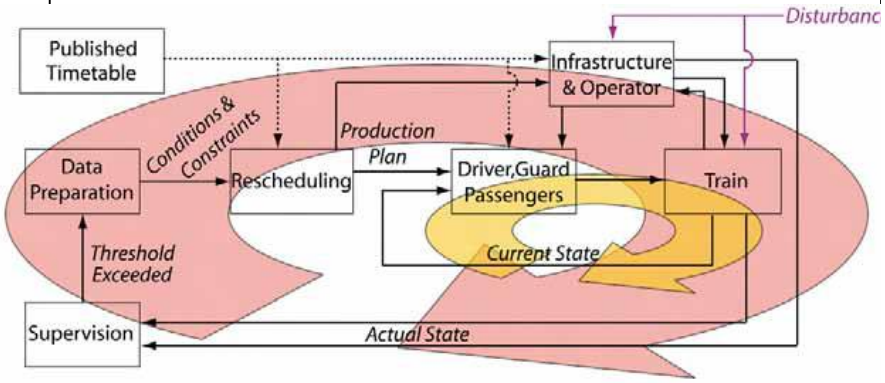
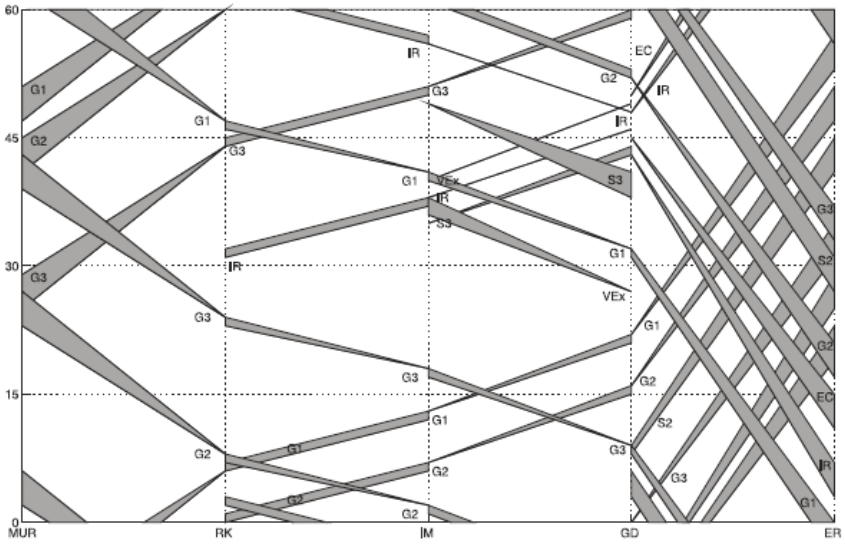


2004-2009: Marco Lüthi and Gabrio Caimi

- Improving the efficiency of heavily used railway networks through integrated real-time rescheduling, 2009



- Algorithmic decision support for train scheduling in a large and highly utilised railway network, 2009



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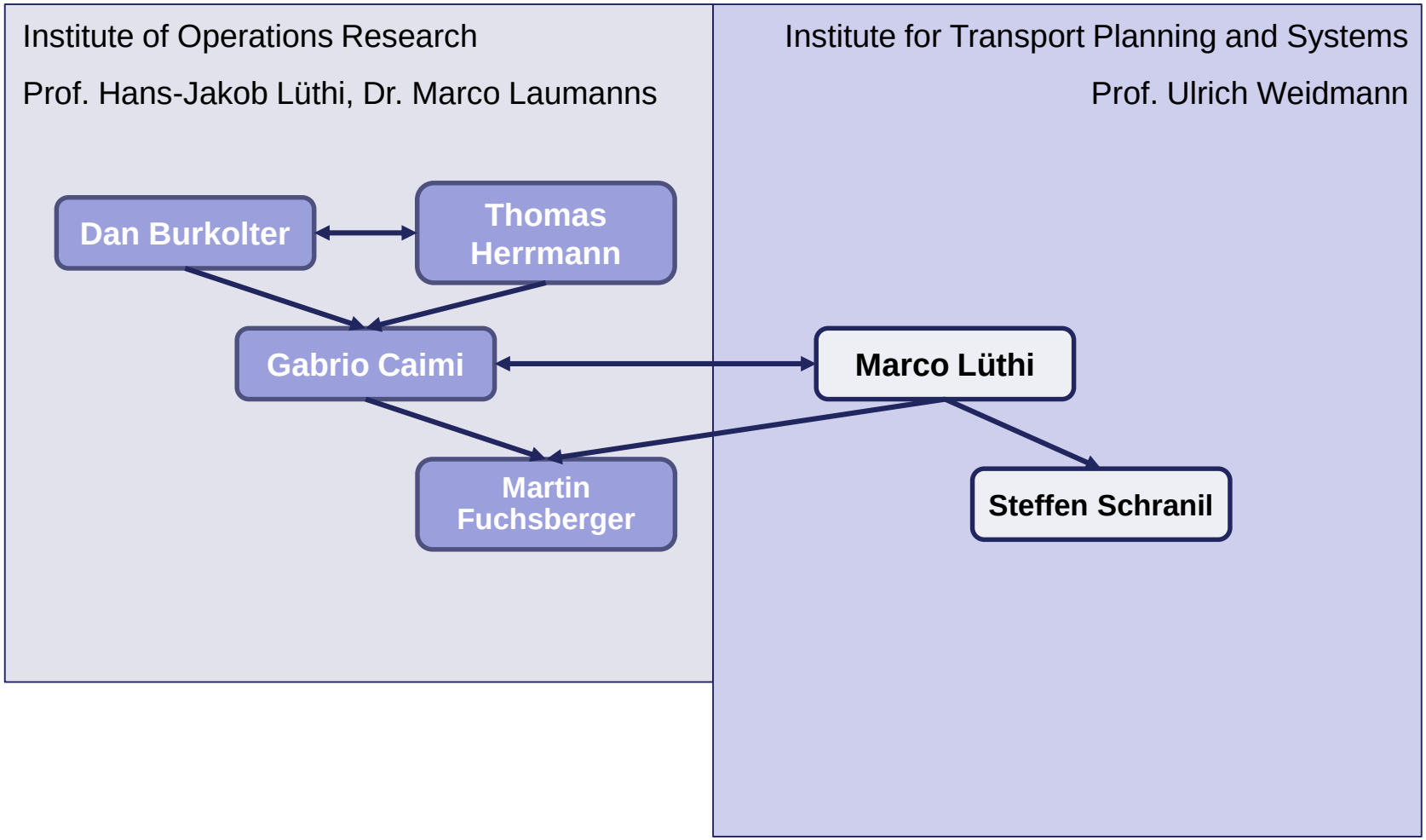
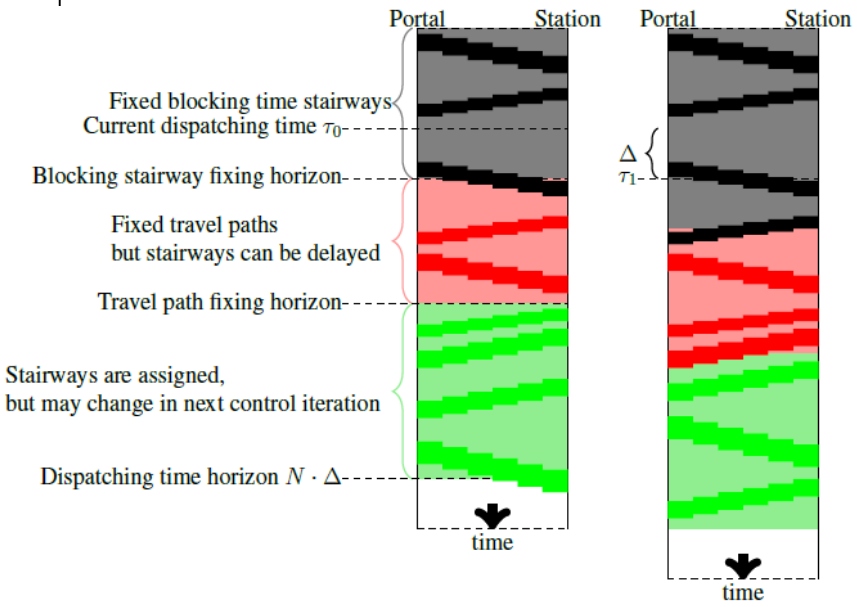
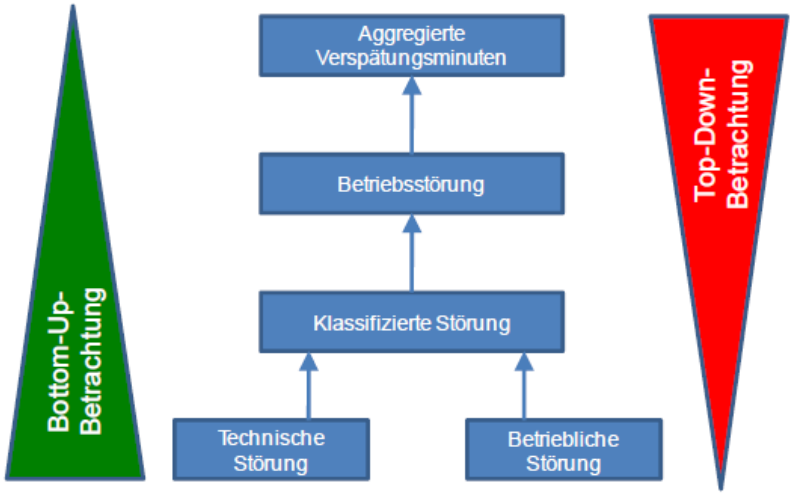


2009-2013: Martin Fuchsberger and Steffen Schranil

- Algorithms for railway traffic management in complex central station areas, 2012



- Prognose der Dauer von Störungen des Bahnbetriebs, 2013



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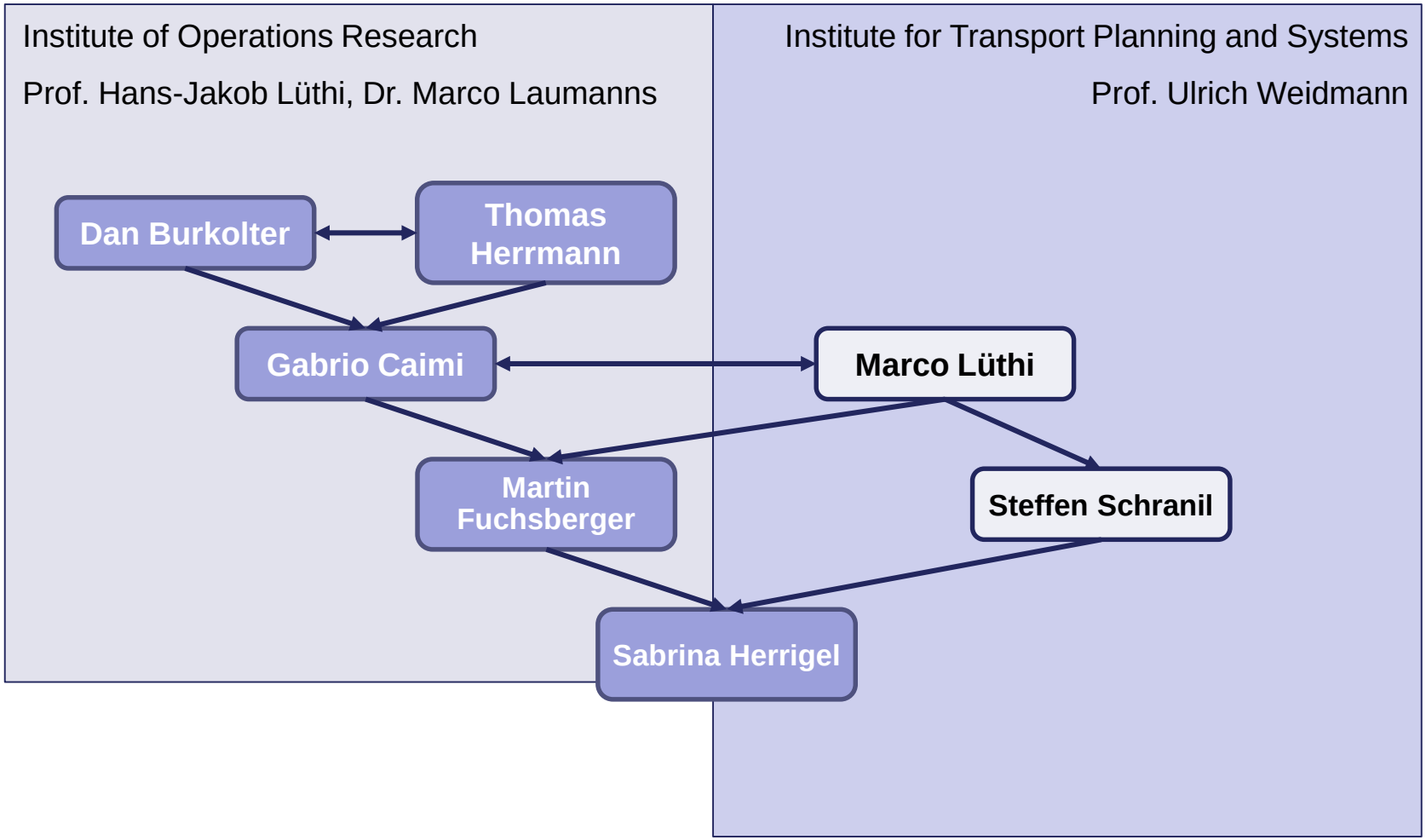
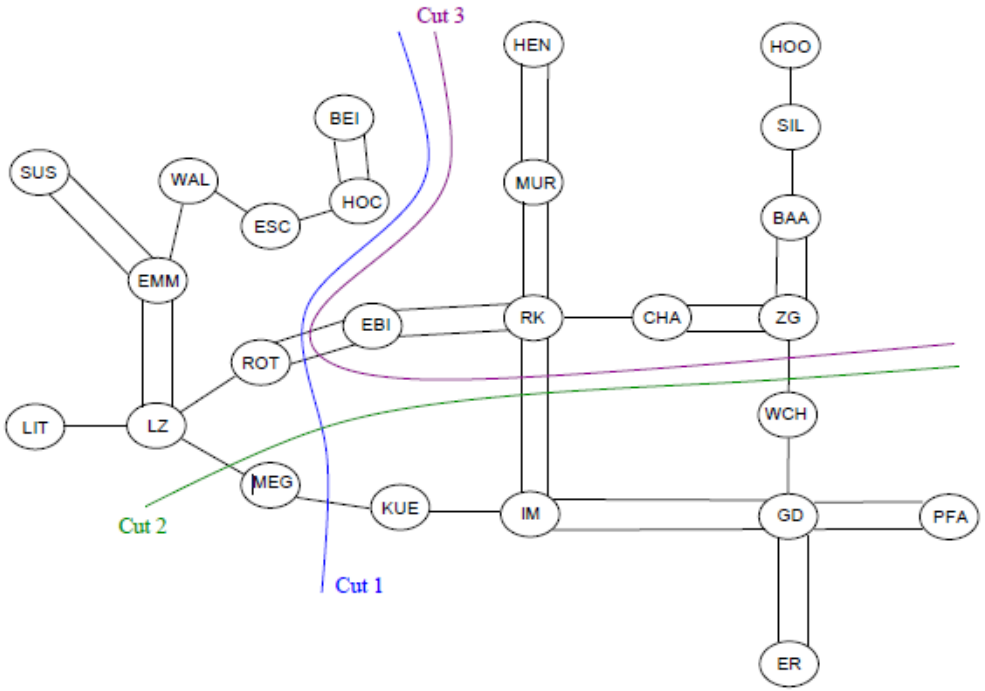


2012-2015: Sabrina Herrigel

- Algorithmic decision support for the construction of periodic railway timetables, 2015



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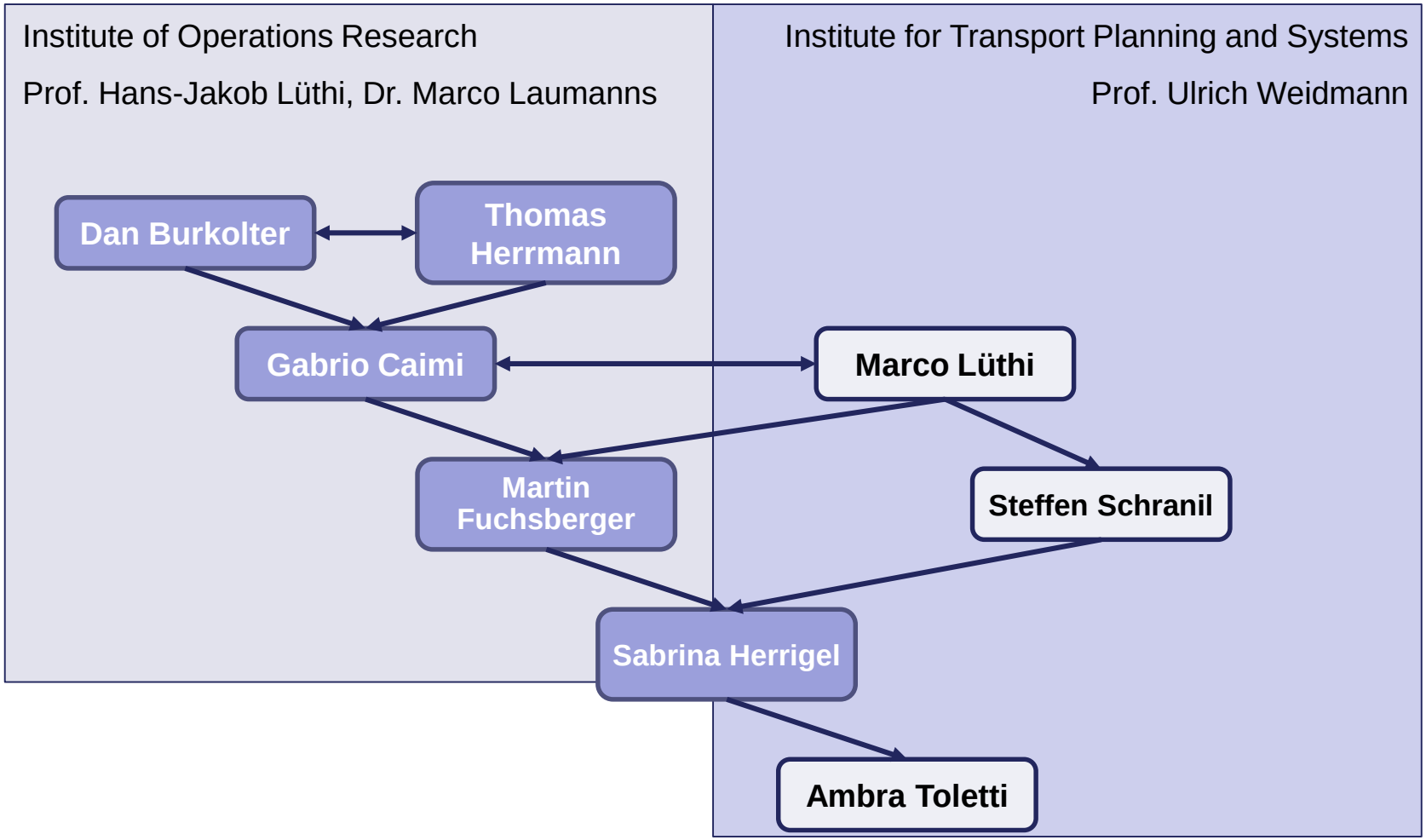
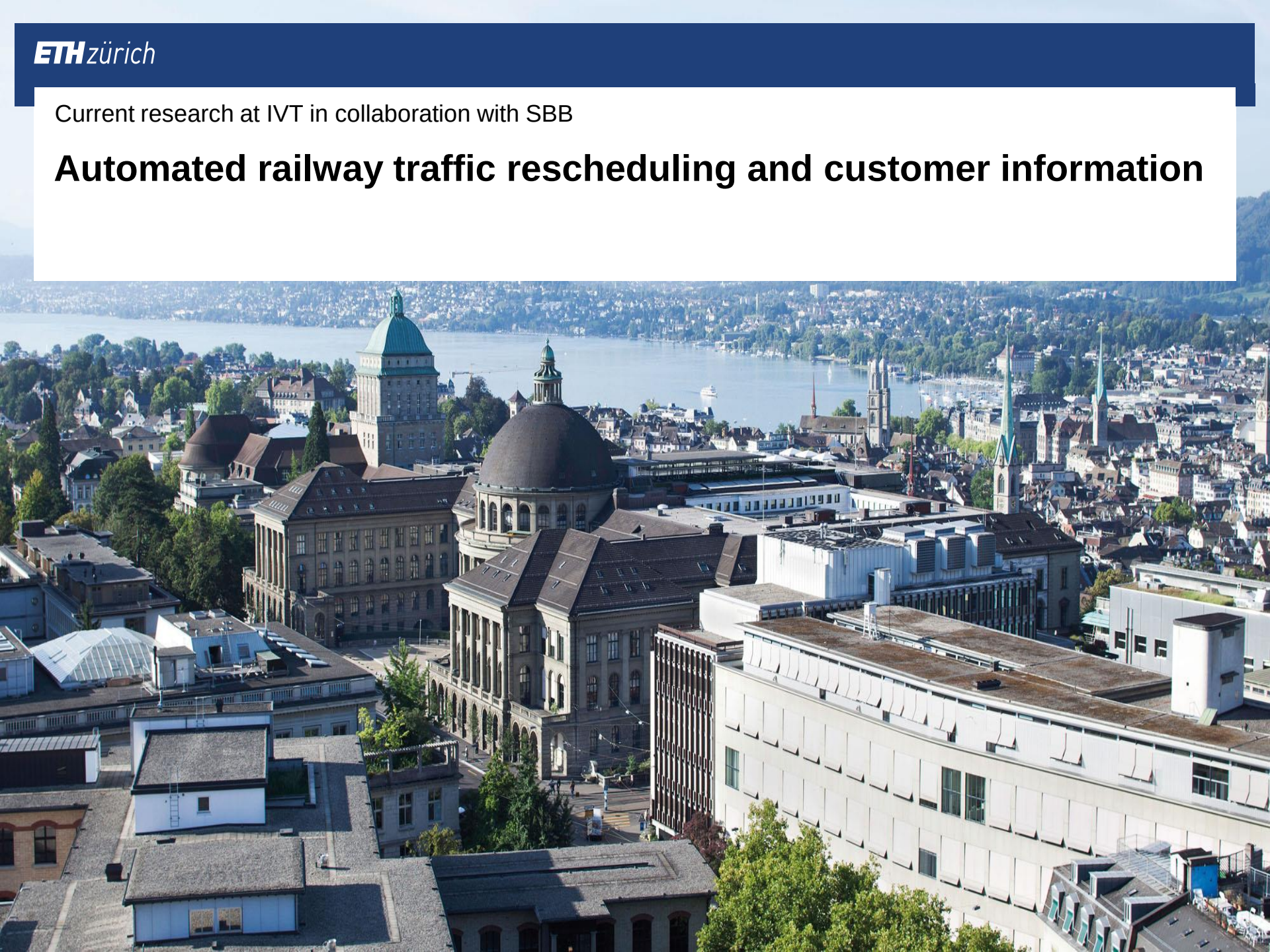


2014-2018: Ambra Toletti

ETH zürich

Current research at IVT in collaboration with SBB

Automated railway traffic rescheduling and customer information



Research question

How can algorithmic real-time rescheduling procedures support the resolution of small disturbances in railway operations in condensation zones and inbound lines, in order to make traffic management automatable and, as a consequence, improve consistency and timeliness of passengers information?

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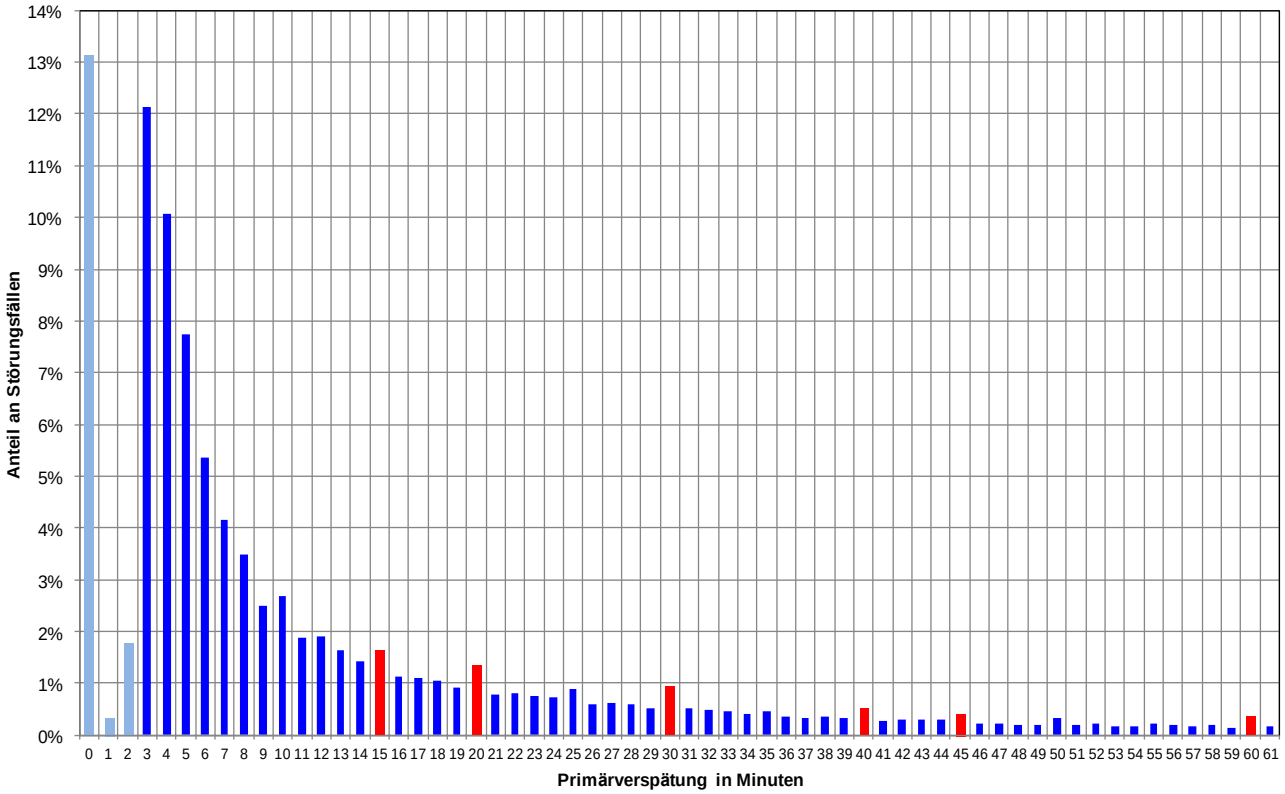
Small disturbances are more frequent than larger ones



[Steffen Schranil, PhD at ETH Zurich, IVT, Transport Systems group]

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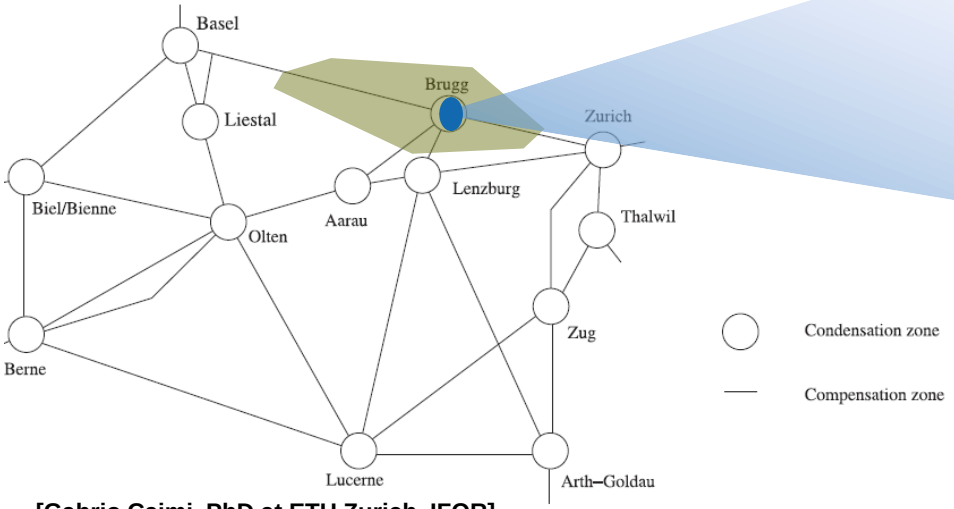
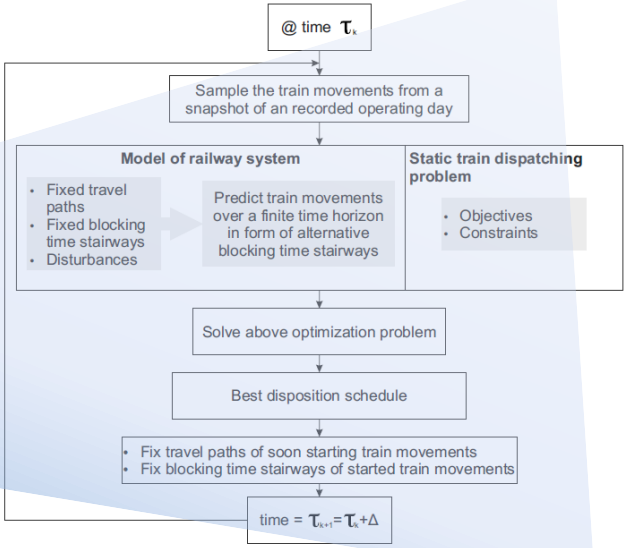
Research question

Network decomposition in condensation and compensation zones and rescheduling algorithms for condensation zones



[Gabrio Caimi, PhD at ETH Zurich, IFOR]



[Martin Fuchsberger, PhD at ETH Zurich, IFOR]

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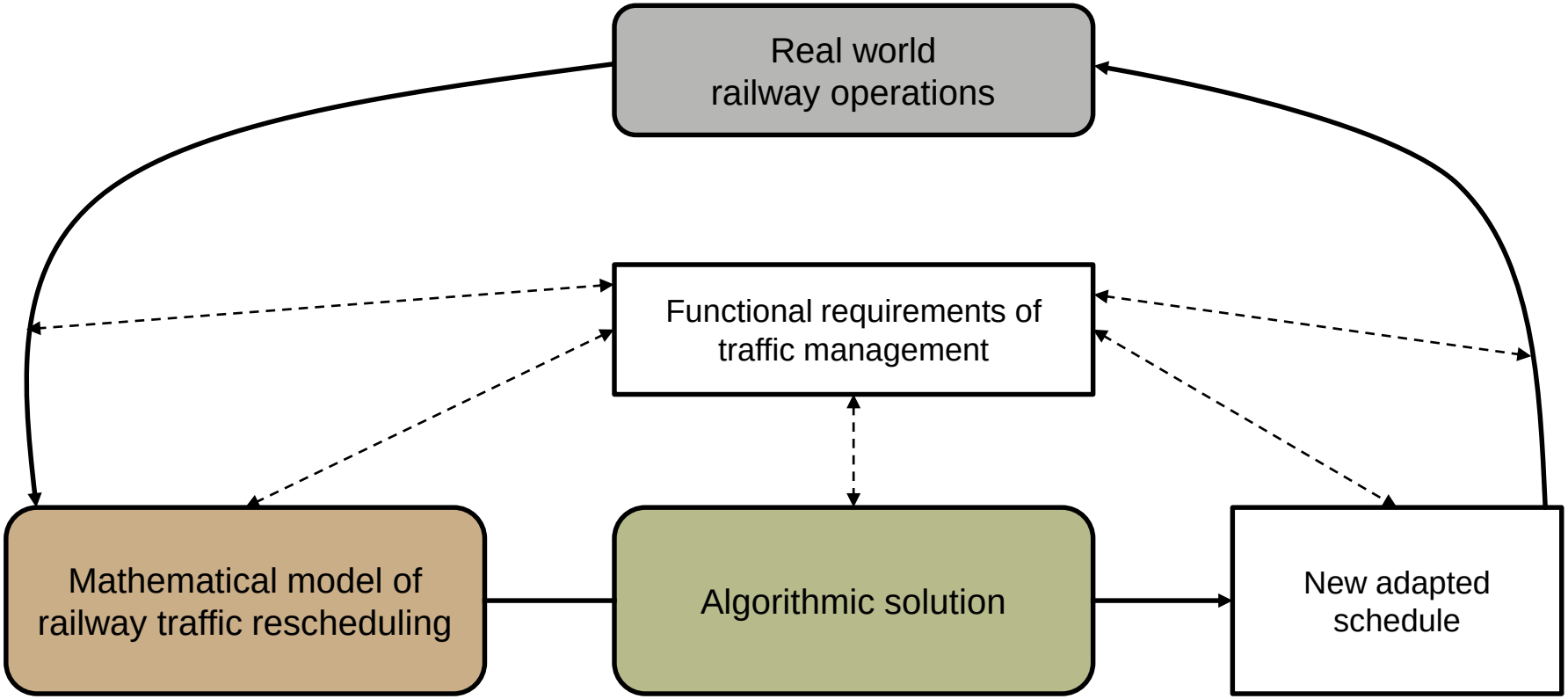
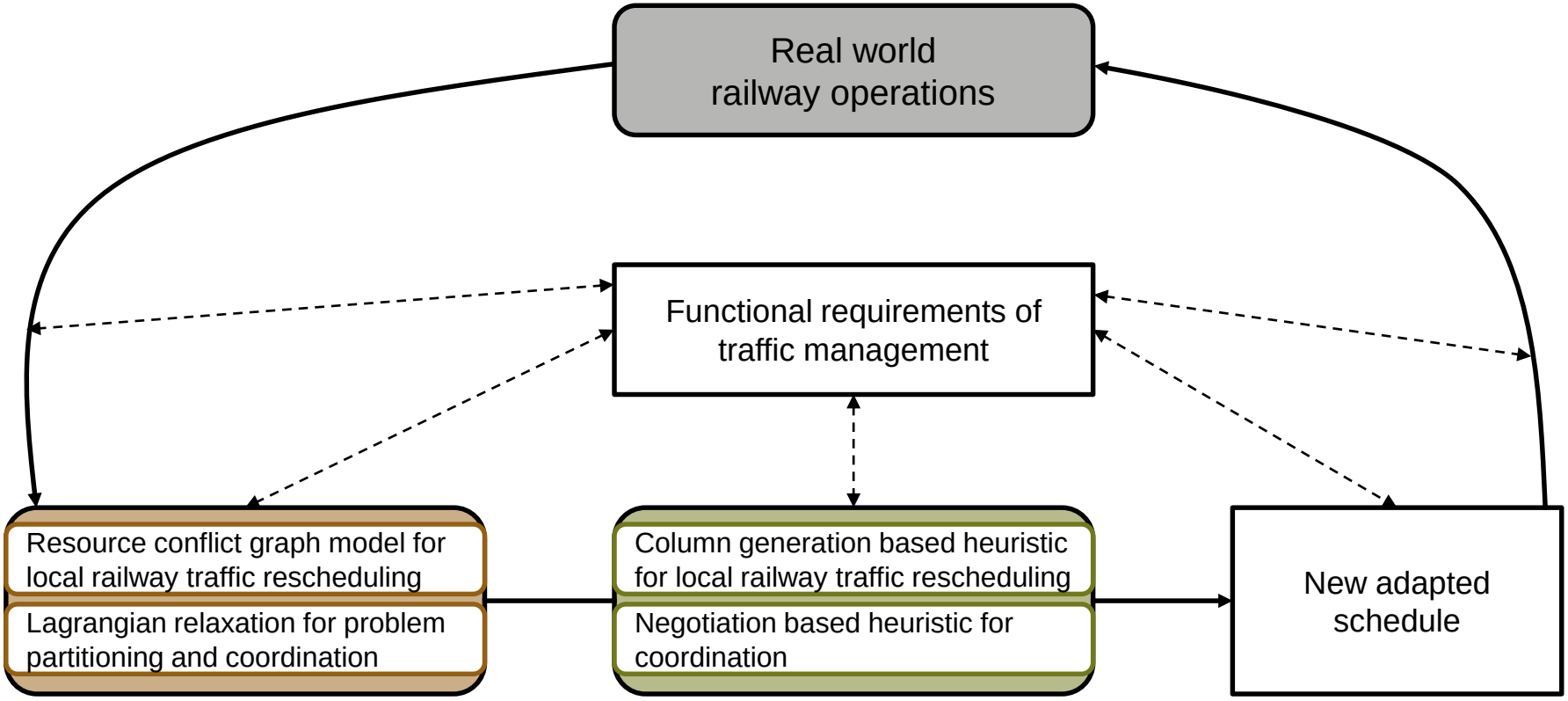
How can algorithmic real-time rescheduling procedures support the resolution of small disturbances in railway operations in condensation zones and inbound lines, in order to make traffic management automatable and, as a consequence, improve consistency and timeliness of passengers information?

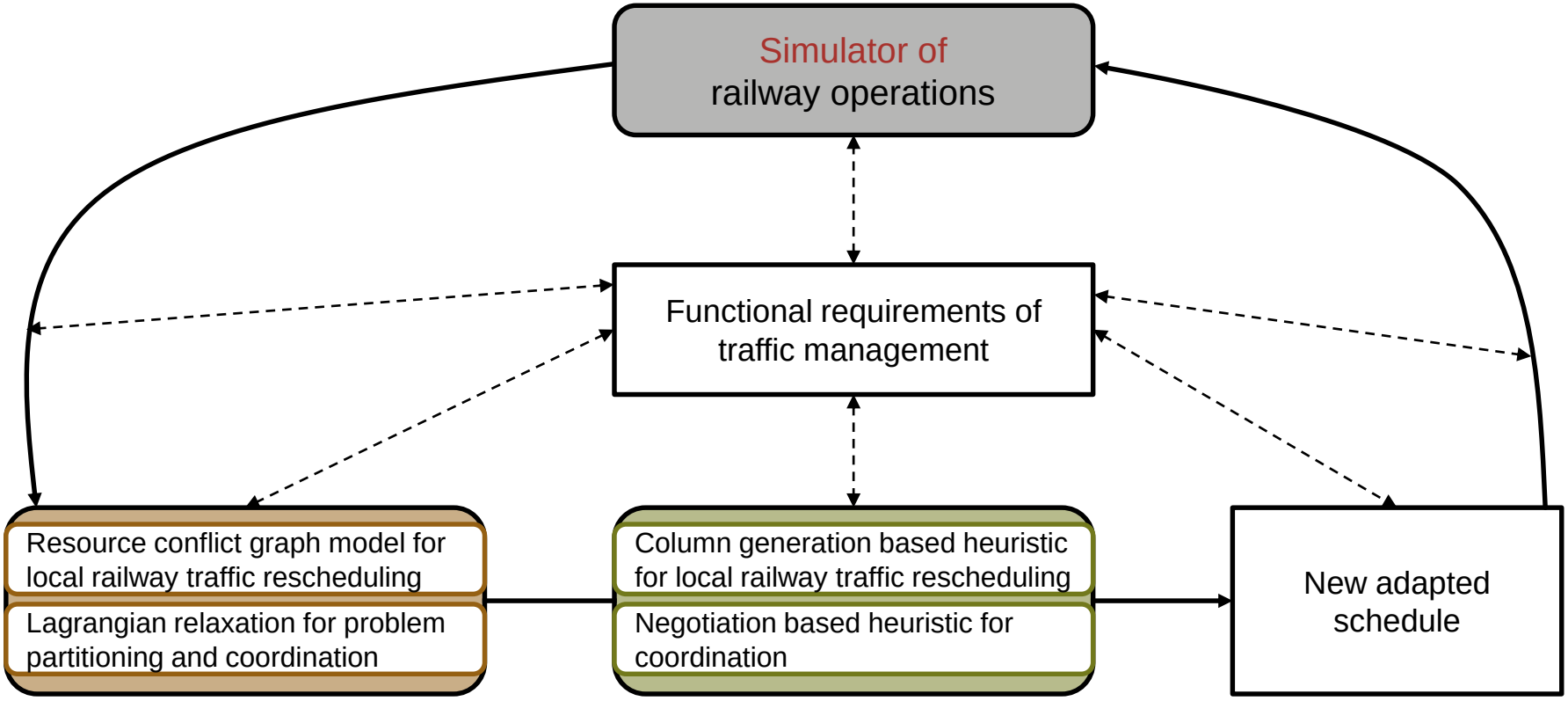
Methodology



Methodology

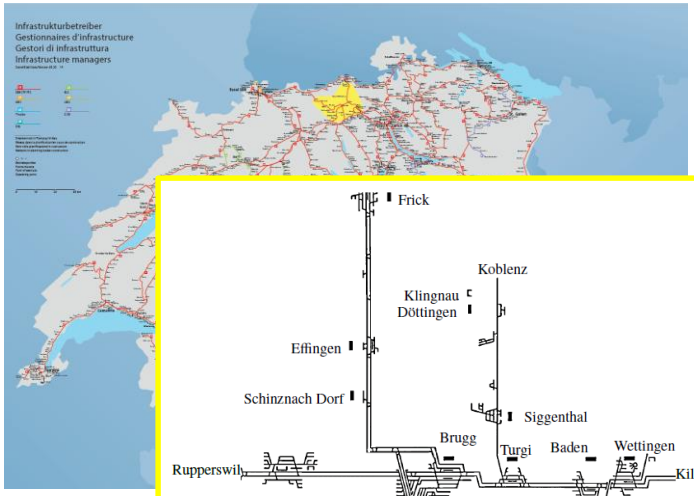


Methodology



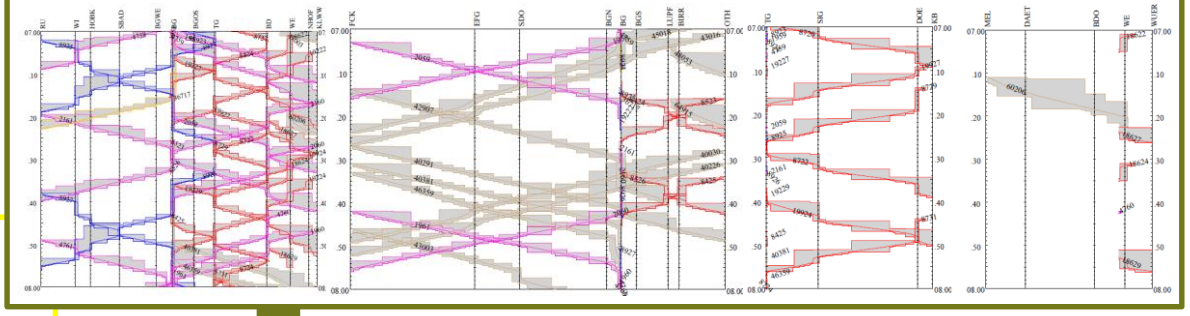
Experimental setup

Infrastructure (track-circuits granularity)



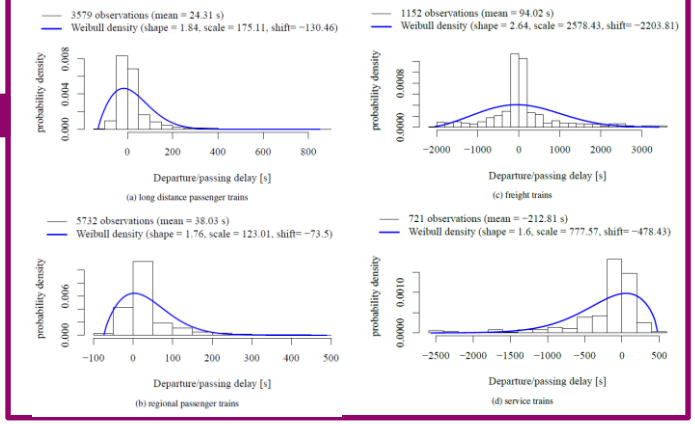
[SBB AG]

Official Timetable 2017, 06:45-08:00



OPEN TRACK

Delay distributions (operations data SBB)



Rolling stock

[Pixabay.com]

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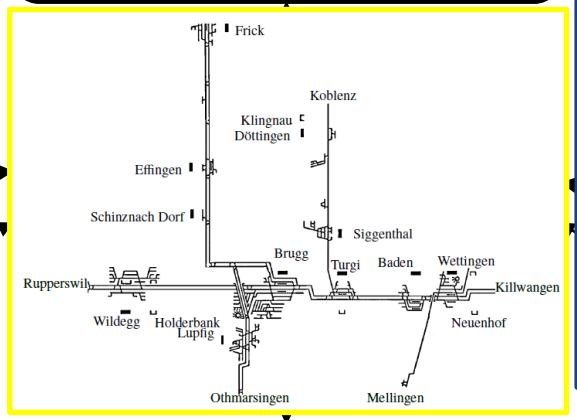
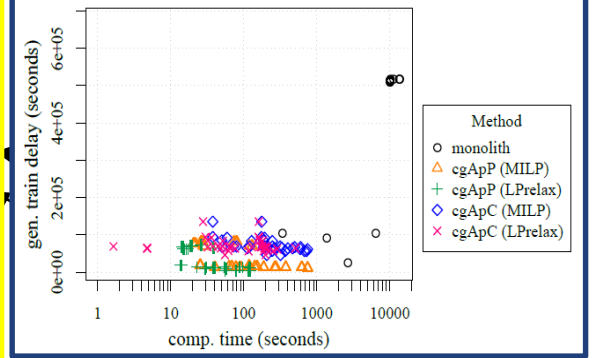
Experimental results

The new adapted schedules built according to the resource conflict graph model are feasible.

Simulator of
railway operations



The column generation heuristic decreases the computational time of the resource conflict graph model w.r.t. commercial solver.



Resource conflict graph model for local railway traffic rescheduling

Lagrangian relaxation for problem partitioning and coordination

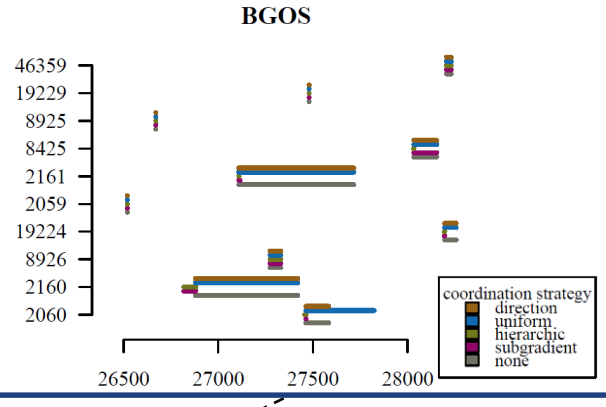
Column generation based heuristic for local railway traffic rescheduling

Negotiation based heuristic for coordination

New adapted schedule

Experimental results

Consistency at portals is not implicitly achieved using the yearly timetable as common reference



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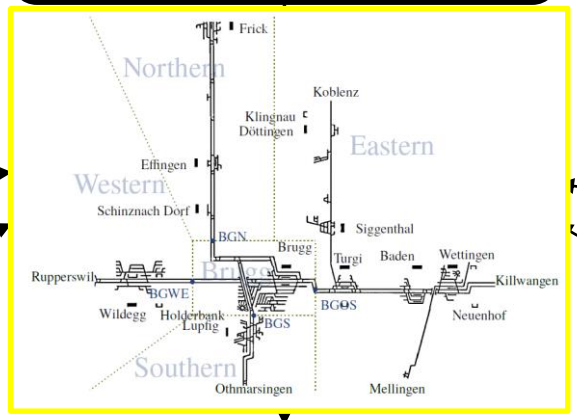

The coordination approach improves consistency of decisions at portals between local rescheduling models

Resource conflict graph model for local railway traffic rescheduling

Lagrangian relaxation for problem partitioning and coordination

Column generation based heuristic for local railway traffic rescheduling

Negotiation based heuristic for coordination

New adapted schedule

Discussion

Insights into the final results of this thesis:

- algorithms can be used to support railway traffic rescheduling;
- the integration of these algorithms into the current traffic support systems is possible;
- as a consequence, passenger information can be improved.

Lessons learnt from collaboration with SBB

- the form of the collaboration evolved during the project;
- at the beginning, support by SBB enabled dive into the topic;
- (direct) access to relevant information has highly contributed to the quality of the thesis.

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Lesson learnt from the past collaboration

From the industrial point of view:

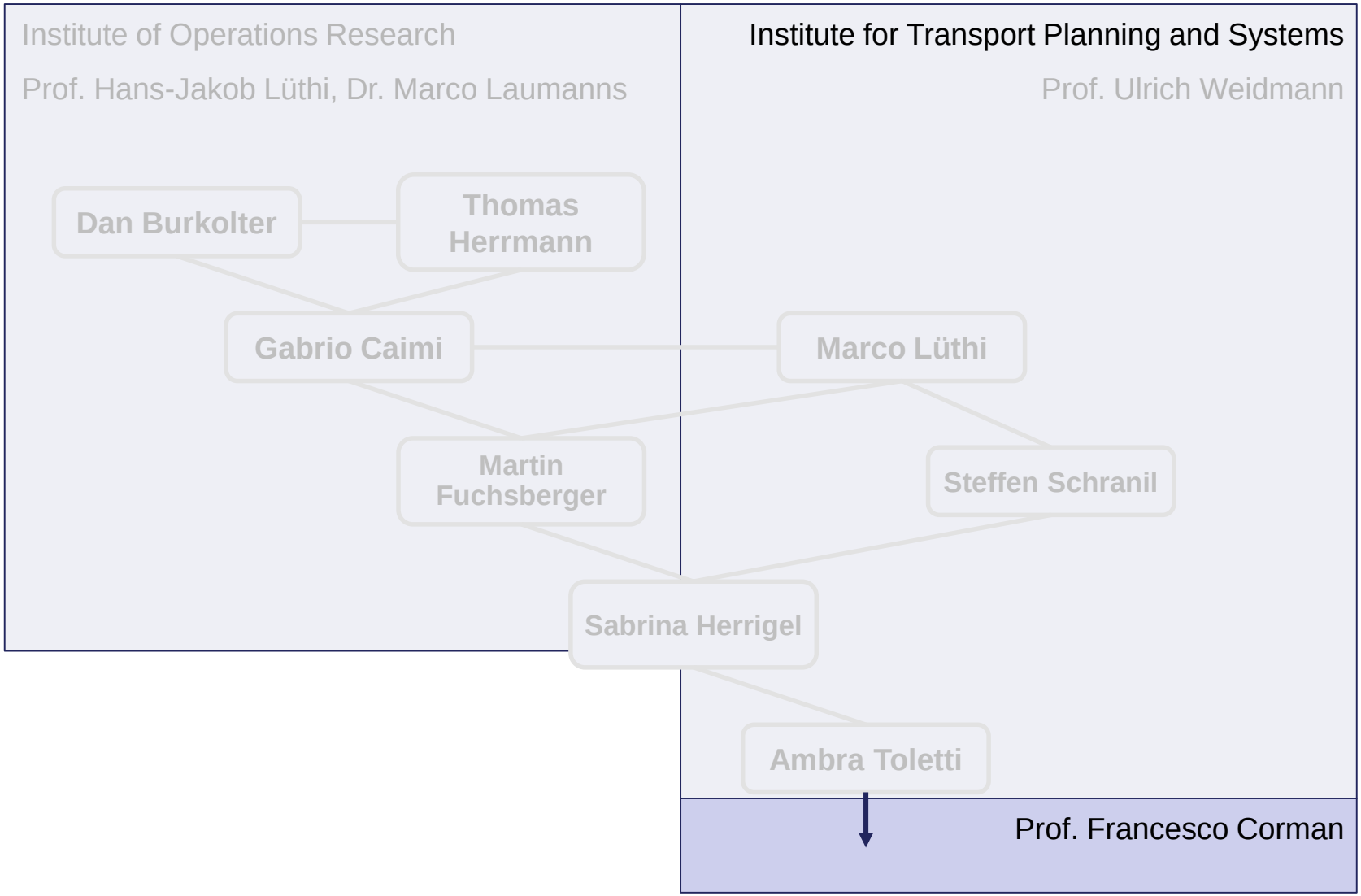
3 key factors for a successful collaboration with academy

1. Good and useful results of the PhD
   → Close collaboration during the PhD thesis, possibility for students to discuss with specialists and have access to data.

2. Have a plan for a stepwise practical implementation
   → Keep going in the topic, integrate the results and have internal resources and organization for the «translation in practice».

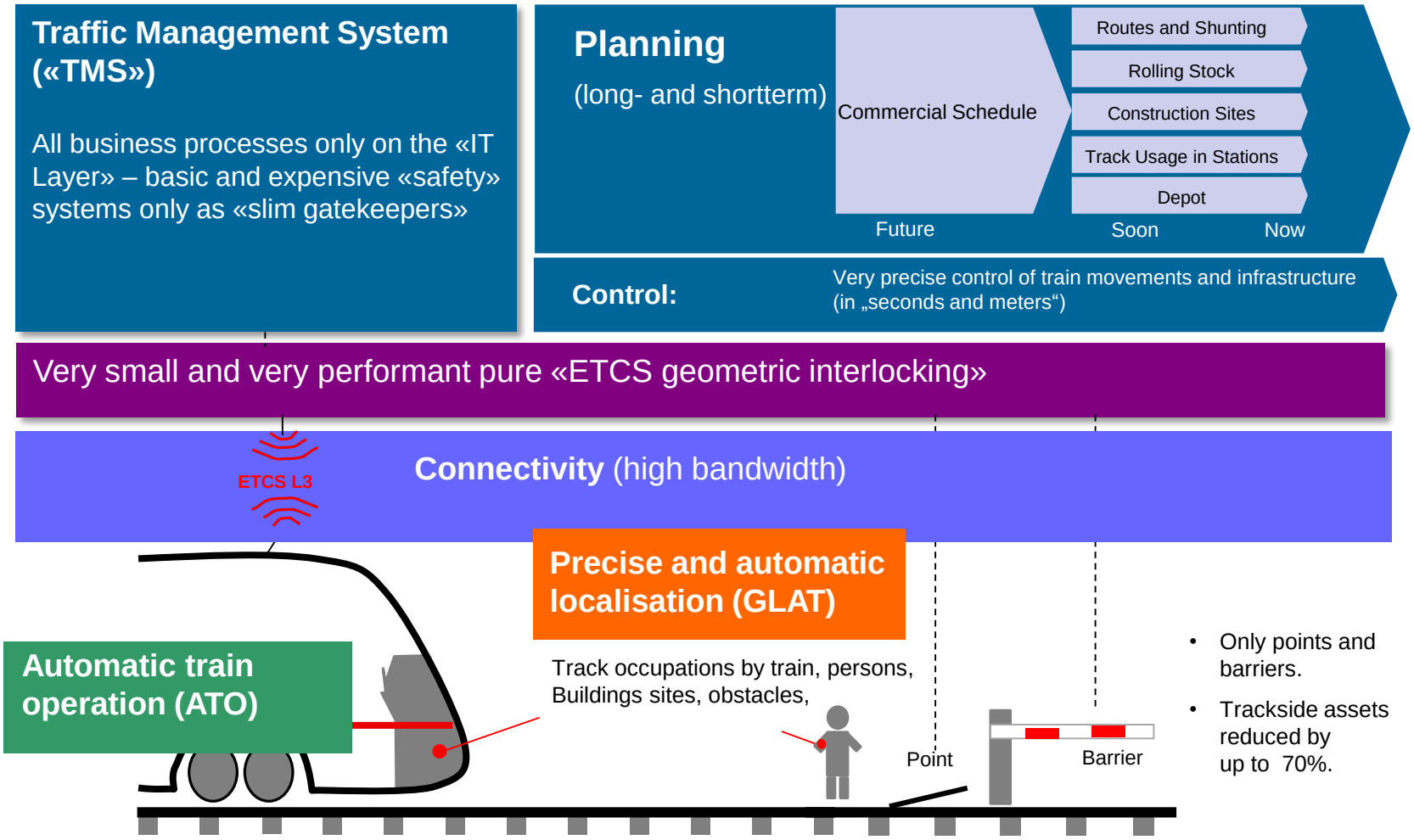
3. Make use of the know-how accumulated by the student during the PhD
   → Hire the person, if possible!

Future collaboration



Challenge for the future

SmartRail 4.0: Key Components.



SmartRail 4.0: Research Topics.

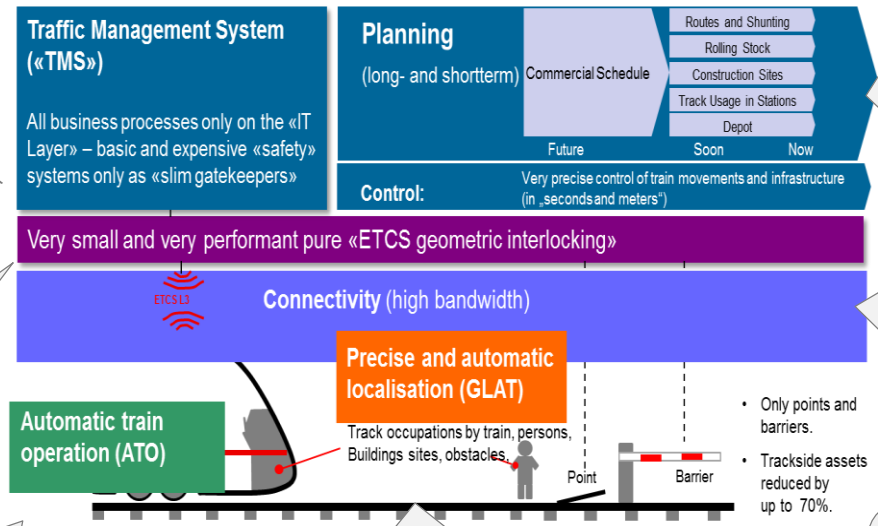
Occupational psychology / changing job profiles

Using simulation for whole-system optimization.

Capacity effects:
- How to increase capacity?
- How to use capacity ?

Automated Planning and Dispatching

Dynamic systems and control loops



Communication bus: achieving safety and reliability over given networks.

Maintaining a safe (SIL-4) image of track topology.

Vehicle architecture for interoperability, upgradability (modularization)

Options for precise, highly available, provably safe, economically viable localisation.

Procedures and techniques to ensure and prove RAMS-characteristics (CENELEC processes).

Analysing, protecting and ensuring for IT-Security.

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«Questions?»