

Disturbance management: Some insights from projects BLIXTEN I and II

Blekinge Tekniska Högskola Karlskrona, Sweden

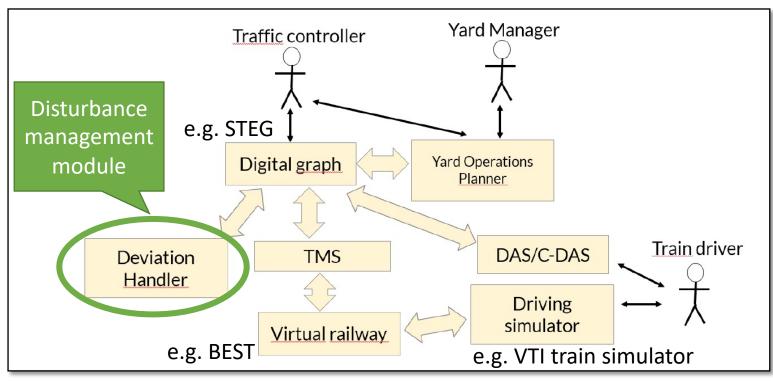
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Real-time railway timetable rescheduling

Components and actors in advanced real-time railway network management



Source: M. Joborn, J. Törnquist Krasemann, B. Thorslund, S. P. Josyula, Z. Ranjbar, T. Liden, M. Wahlborg, "Description of a decision support tool aimed at advanced Real Time Network Management and requirements for a demonstrator", 2020. (FR8Rail II Deliverable 3.2). <u>http://www.diva-portal.org/smash/record.jsf?pid=diva2:1510579</u>



Scope and research focus

Human-computer interaction

Disturbance management from Infrastructure Manager's perspective:

- □ Prioritizing a train over another
- Retiming trains
- □ Allocating alternative tracks

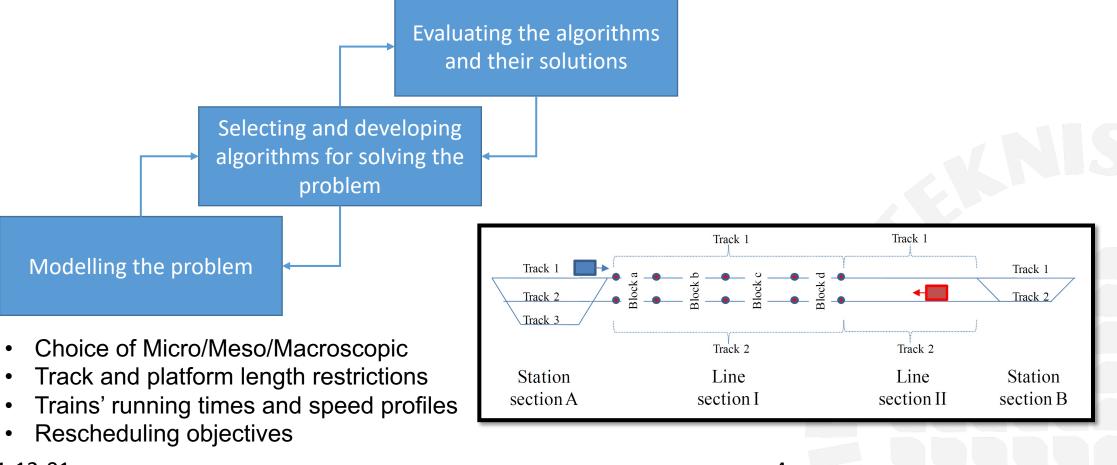
Global train rerouting Train cancelations, etc. Train crew schedules Rolling stock schedules

Disruptions



Some challenges

- ➤ How to model the problem?
- How to design and implement the algorithm?
- > How to analyze its applicability, strengths, and limitations?



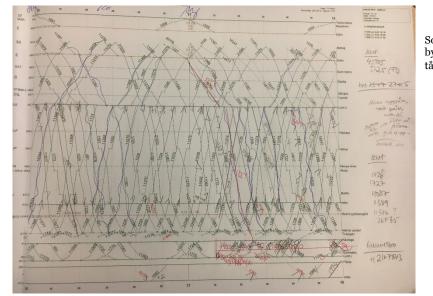


State of the practice

> Only very few examples of computer algorithms for rescheduling

Regional lines in Italy (2011- ongoing).
Certain lines in Latvia (2017-ongoing).
A system in greater Oslo area (not in operation yet).

➢ In Sweden, disturbances are handled...



Source: Trafikverket. Permission to be used was given by Sandra Stefanovic, sektionschef vid tågtrafikledningen/DLC Malmö in Oct 23rd, 2017.



Research need: Evaluating algorithms

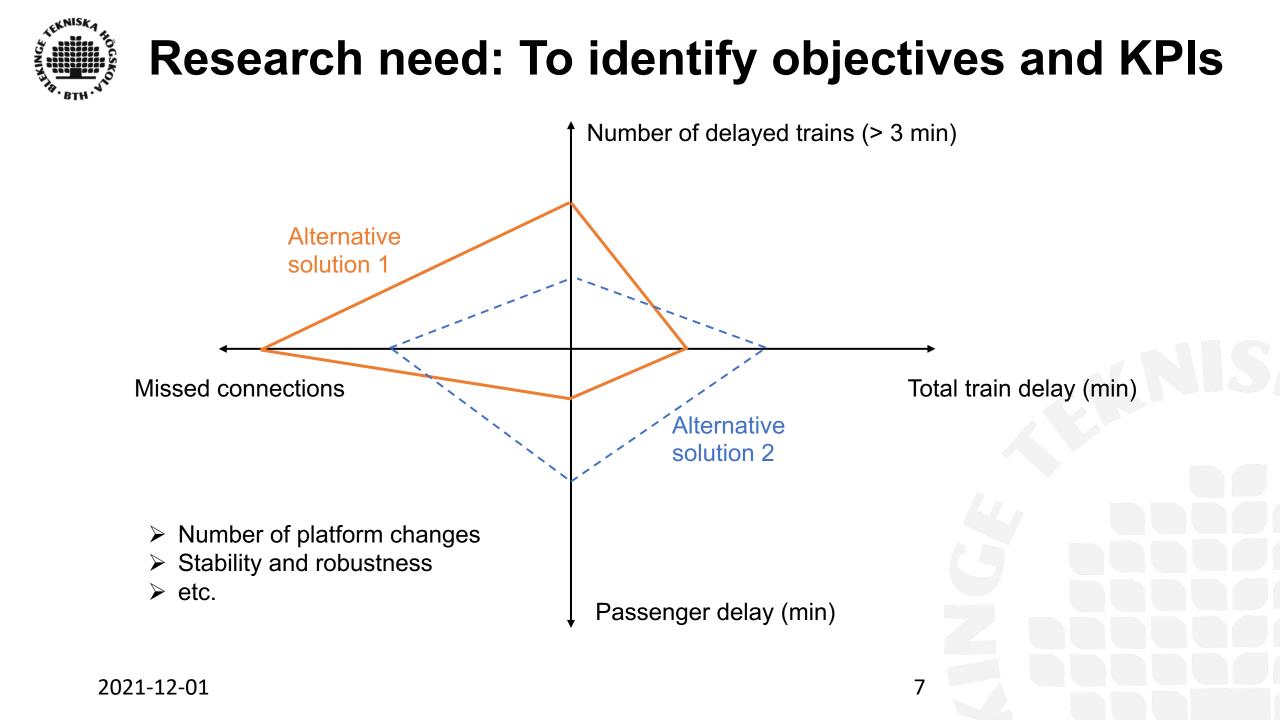
A wide range of solution approaches:

- Local rules and conflict resolution principles (e.g., FCFS)
- Various mathematical formulations solved with exact methods (e.g., using commercial solvers)
- Problem decomposition techniques:
 - Decomposition in time, e.g., a rolling-time horizon
 - Decomposition in space, e.g., making the decisions at different levels and solving iteratively.
- > Algorithmic approaches, including a combination of above.

All approaches have their own strengths and limitations!

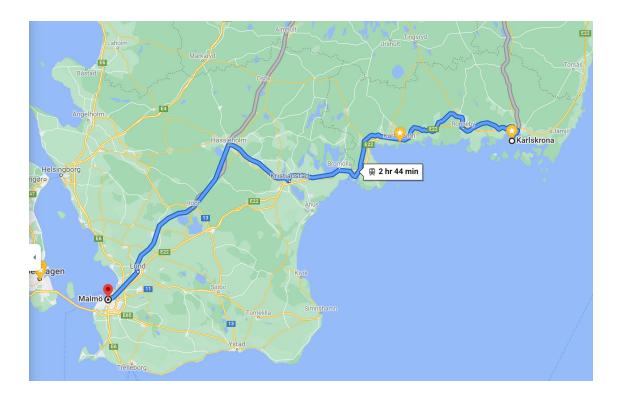


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Results and conclusions from a Swedish case study



- The railway stretch between Karlskrona–Malmö, via Kristianstad and Hässleholm
- 90 sections, 42 stations
- Mixed traffic: Regional passenger trains, freight trains, long-distance passenger trains



Blekinge Kustbana



Source: Page 10 of the document *Blekinge kustbana, fördjupad utredning för etapp 2* <u>https://www.trafikverket.se/contentassets/a0</u> <u>a574ba8c6743bd87cd23febdd07a98/fordjupa</u> <u>d utredning trafikverket bkbe2 signerad.pdf</u>



Train timetable

	15:50 1	6:00	16:10 16:20	16:30	16:40	16:50	17:00	17:10 17:20	17:30	17:40	17:50	18:00	18:10	18:20	18:30	18:40	18:50 1	9:00	19:10	19:20	19:30	19:40	19:50 20	:00 20:1	0 20:):20 20
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A calibrated version of the train timetable from October 2016 for a weekday.

Timetable from Karlskrona to Kristianstad (4:00 PM to 9:00 PM)



Train timetable (contd.)

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 Currently operational timetable contains more traffic nowadays

Timetable from Hässleholm to Malmö (4:00 PM to 9:00 PM)



An example rescheduling scenario

Trains	Disturbance location	Wall-clock time, Disturbed train		Potential conflicts	Extended runtime
107	Hässleholm:Mellby	5:40 PM, Westbound freight train	50% increase in its runtime	23	37 min

Solution	Total delay of trains at final stations	Solutions from our tailormade
Rescheduling solution 1	55 min	rescheduling algorithm
Rescheduling solution 2	48 min	

Q) How can the numerical and visual analysis of the solutions be beneficial?

Solution	Total delay of trains at final stations	Trains with secondary delay	Platform track reassignments
Rescheduling solution 1	55 min	1	1
Rescheduling solution 2	48 min	3	0

2021-12-01

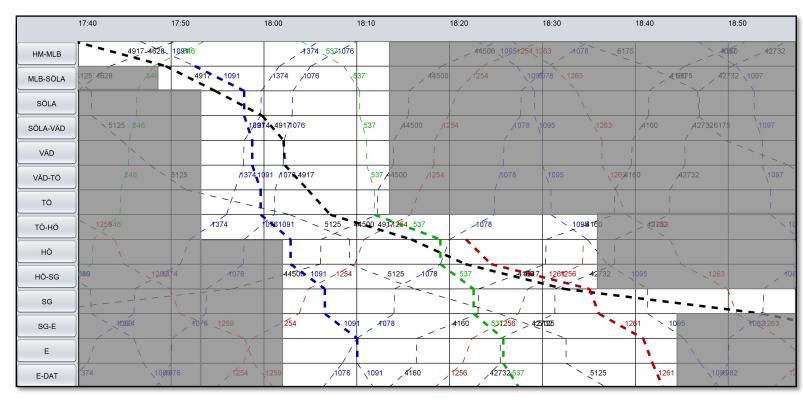


An example rescheduling scenario

Trains	Disturbance location	Wall-clock time, Disturbed train (remaining events)	Initial delay	Potential conflicts	Extended runtime
107	Hässleholm:Mellby	5:40 PM, Westbound freight train 4917 (35 events)	50% increase in its runtime	23	37 min
17:40 HM-MLB MLB-SÖLA 125 SÖLA 125 125 125 125 125 125 125 125	4917.4628.109946 4628 546 4917 1091 1374 10 1 1 1 5125 546 5125 73741091 7076 1 1 125946 7374 0181091	537 A4500 A254 A078 1095 1263	4 16075 422 32 1097 1 1 1 A160 A27 32 6175 1097 1 1 1 4160 A27 32 6175 1097 1 1 1 420262 1 1 1095 1263 40 1095 1095 1022 263	disturbe	ne initially d freight periences a



An example rescheduling scenario (contd.)



- Which alternative to prefer over the other and why?
- What other KPIs are important to consider?

An alternative solution found by the algorithm:

- A smaller total final delay at stations,
- But three trains with secondary delays in their route.

Algorithm's	Algorithm's
main	alternative
solution	solution
(55 min,	(48 min,
1 train)	3 trains)



Some conclusions

- Numerical evaluation of rescheduled timetables using various KPIs is important (we proposed an evaluation framework)
- Different algorithms may be suitable for different types of disturbances (we evaluated an exact algorithm and a tailormade algorithm)
- Possible to increase the modelling detail while retaining the algorithm's speed (we increased the detail of problem model)
- Possible for the dispatcher and the algorithm to complement each other (to quickly find the best rescheduled timetables)



Thank you for the attention

Questions and Discussion

Disturbance management: Some insights from the project Blixten II

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