Strategisk anläggningsplanering för balansering av underhåll och tågtrafik- STAPLA

KAJT dagar, 2019-04-12, Borlänge

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Problem statement

- Main motivation

Gives flexibility, but high maintenance costs.

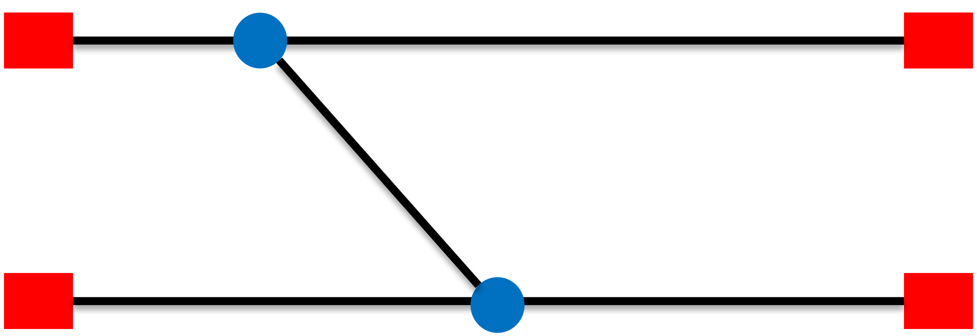
- How can we remove switches and crossings while maintaining the railway traffic properly?

Purpose / content

- Develop a basic model
  - Through traffic, without shunting movements
  - Apply on small realistic case

Railway Network

- Locations – red points
- Tracks – black lines
- Switches and crossings – blue points



Railway Network Reduction Problem

Given

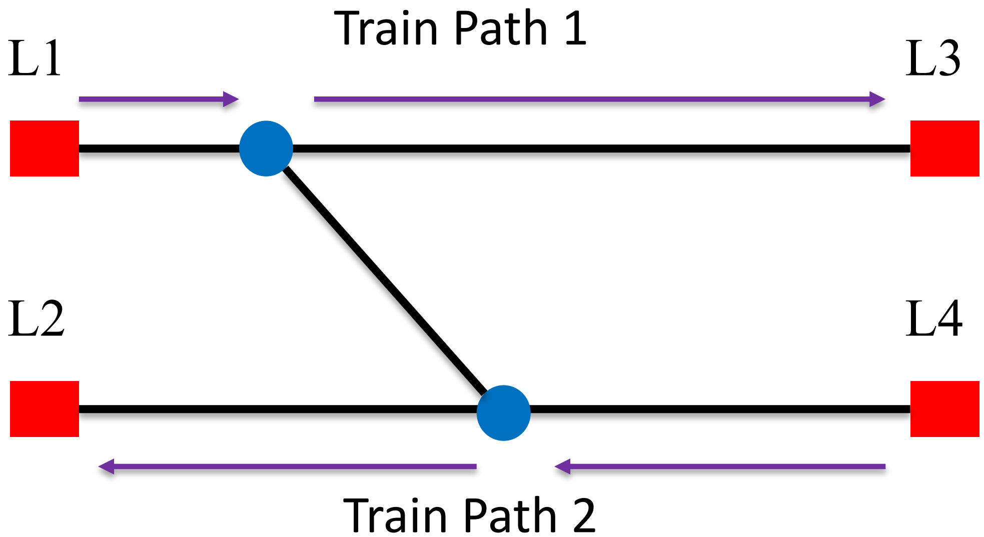
- An existing network layout
- Set of traffic relations (between locations)
- All possible paths (by using tracks/switches) for these traffic relations

Railway Network Reduction Problem - continue

The aim is to decide a min-cost selection of tracks, switches and paths

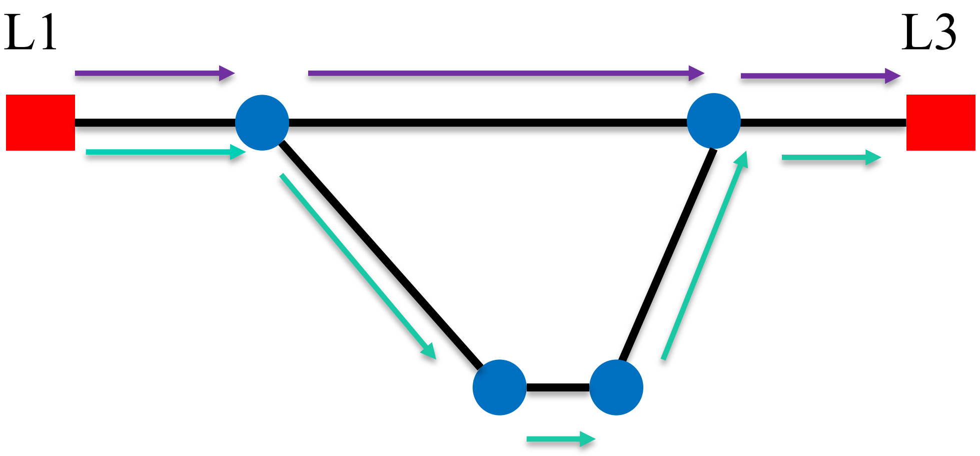
- All traffic relations are covered
- All traffic requirements for simultaneous traffic relations and overtaking possibilities are fulfilled

Simultaneous Traffic Relations



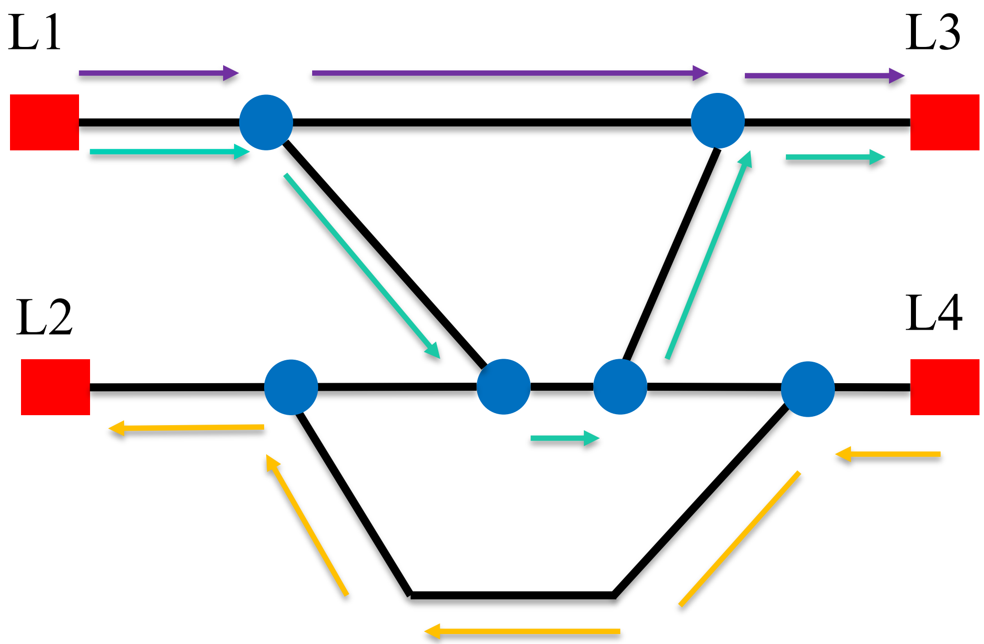
- No track section in common

Overtaking Traffic Relations

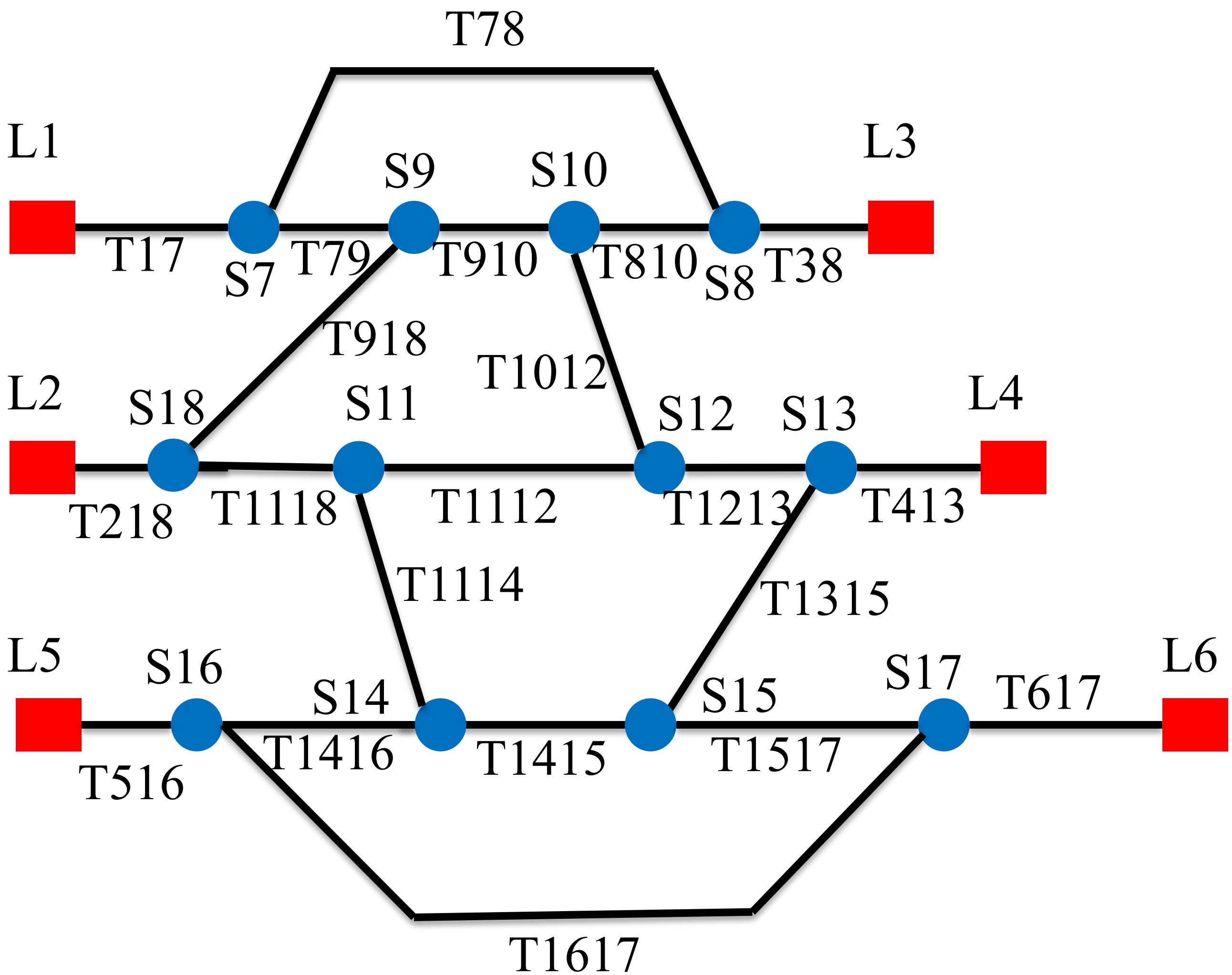


Same start/end location but differing intermediate part of certain track length (so stopping train will fit)

Combination of Overtaking Traffic Relations and Simultaneous Relations



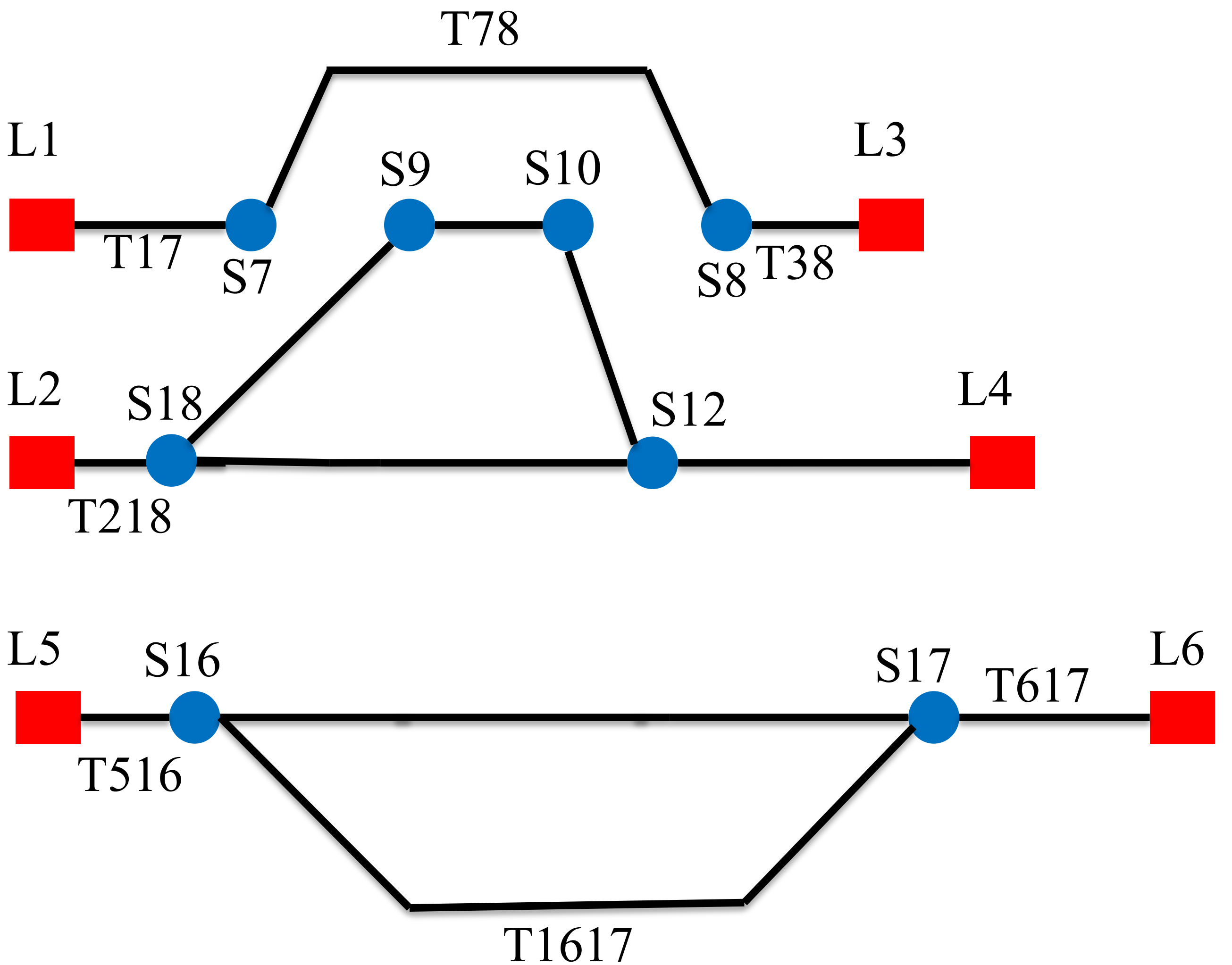
Toy Network
Traffic Relations: (L1-L3) (L2-L4) (L5-L6)



Just Simultaneous Traffic Relations

All switches and some tracks are removed.

Overtaking Traffic Relations: (L2-L4) (L5-L6)
Simultaneous Traffic Relations: (L1-L3) (L2-L4) (L5-L6)



The Result

- S11, S13, S14 and S15 and their corresponding tracks are removed.
- The selection of the tracks and switches depend on the traffic requirements !

Data / input

- L: set of all locations
- R: set of all relations, with origins and destinations
- S: set of switches, with normal/straight direction and diverging direction
- P_r: set of paths for relation $r \in R$. Each path $p \in P_r$ defined as a sequence of tracks

Traffic requirements

- R_r^{sim}: Set of required simultaneous relations for relation r
- R^{over}: Set of relations where overtaking is required
- R_r^{comb}: Set of simultaneous relations in combination with overtaking relation $r \in R^{over}$

Derived sets

- P_s^b: All paths using switch s in its diverging direction
- P_p^{sim}: All simultaneous paths for path p
- P_r^{over}: All overtaking paths for relation r

Model outline - path based

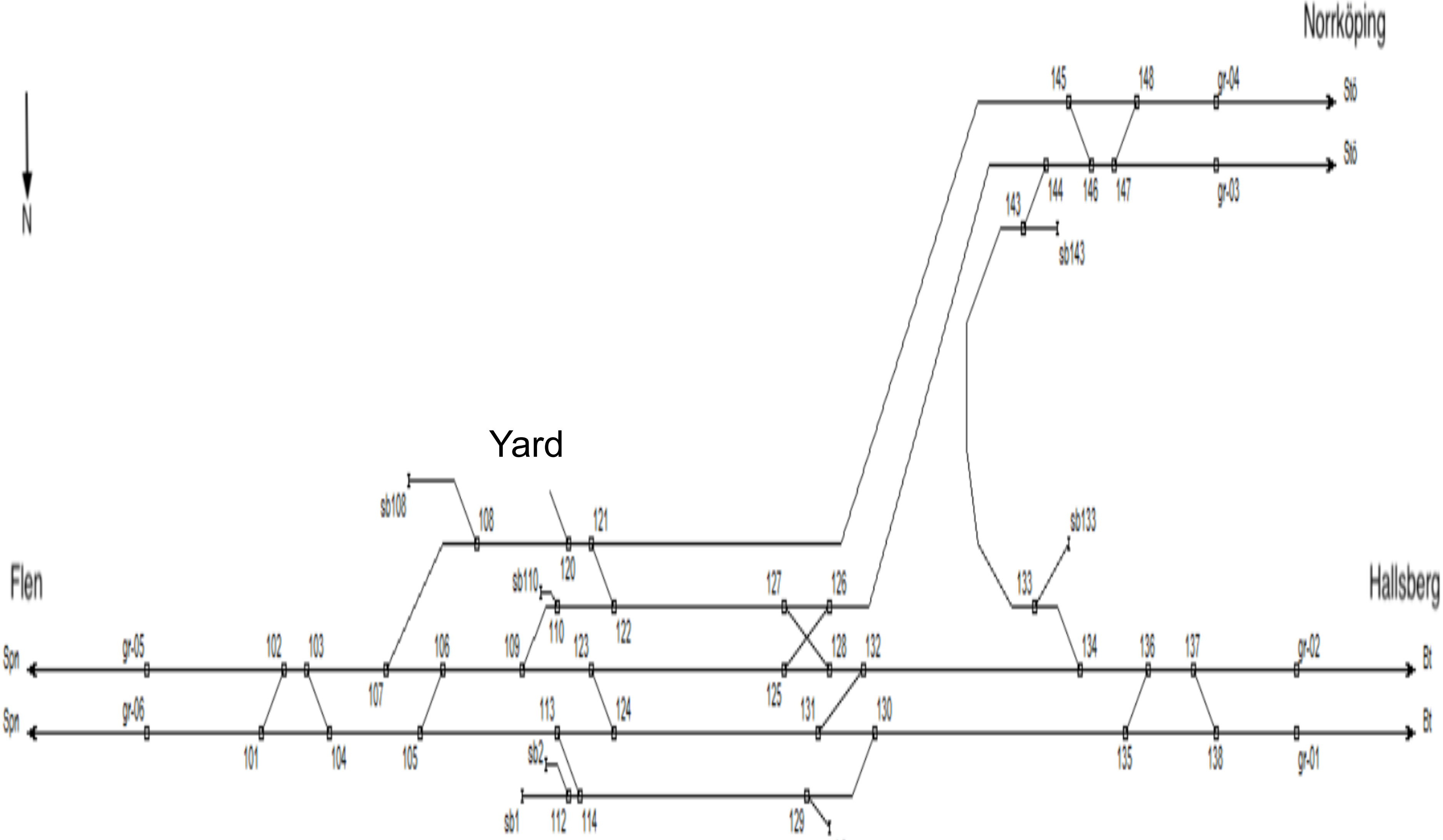
- Variables

  z_p, binary, = 1 if path $p \in P_r$ is selected

  y_s, binary, = 1 if switch $s \in S$ is used in its diverging direction

- Select paths such that minimum number of switches are needed
  - Respect simultaneous relations
  - Respect overtakings
  - Respect combined simultaneous and overtakings

Case Study - Katrineholm Station

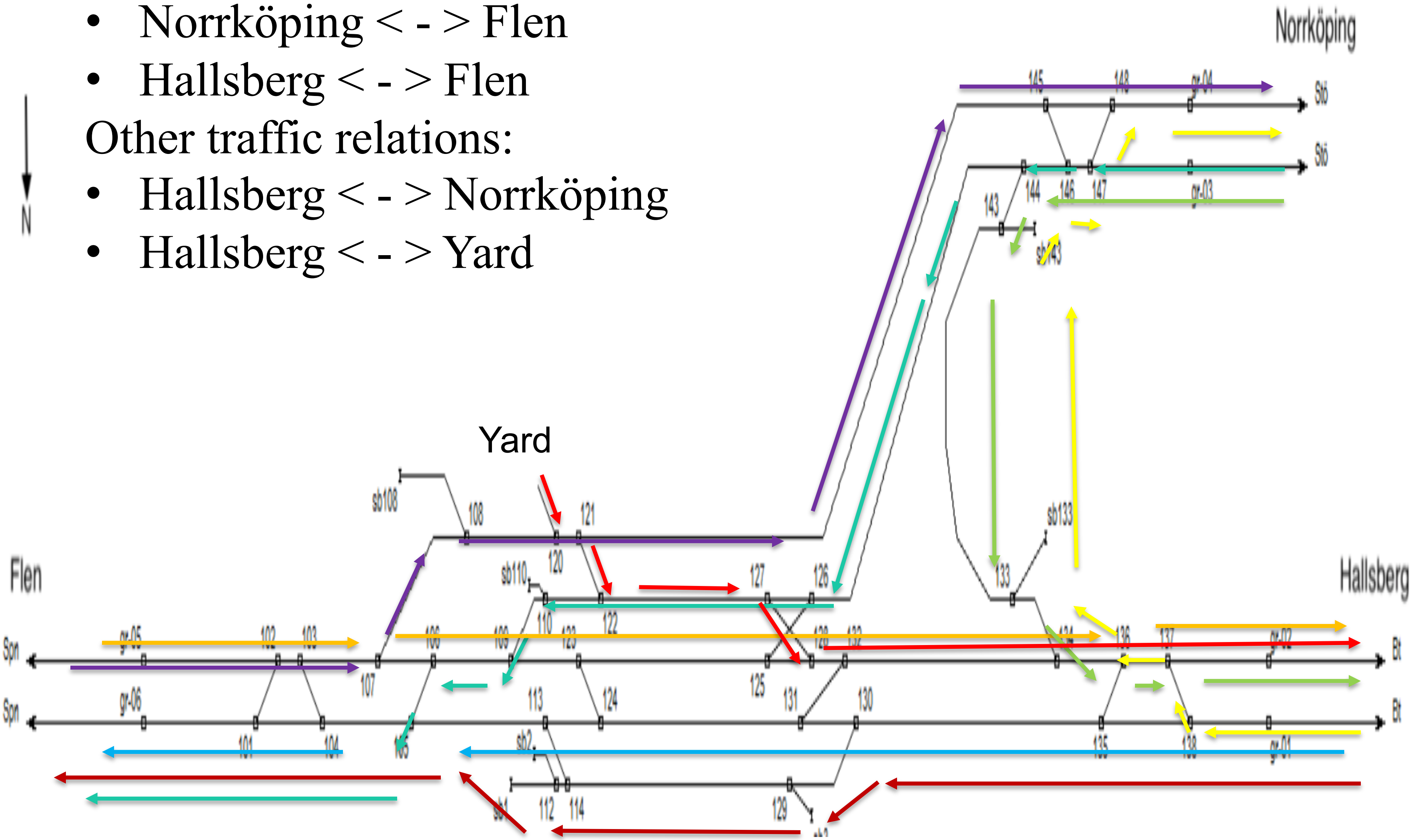


Main traffic relations

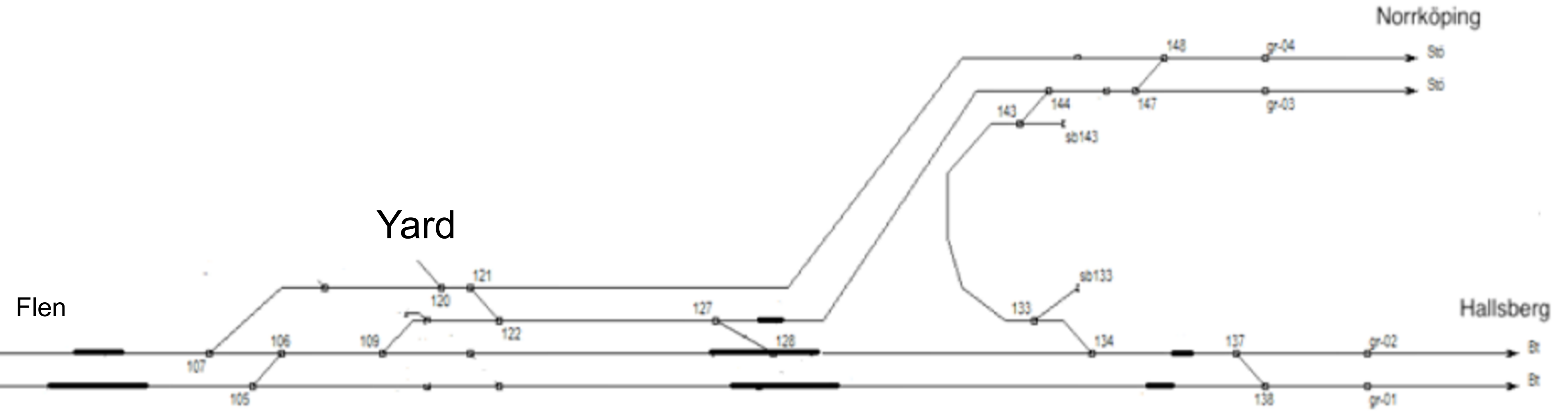
- Norrköping < - > Flen
- Hallsberg < - > Flen

Other traffic relations:

- Hallsberg < - > Norrköping
- Hallsberg < - > Yard

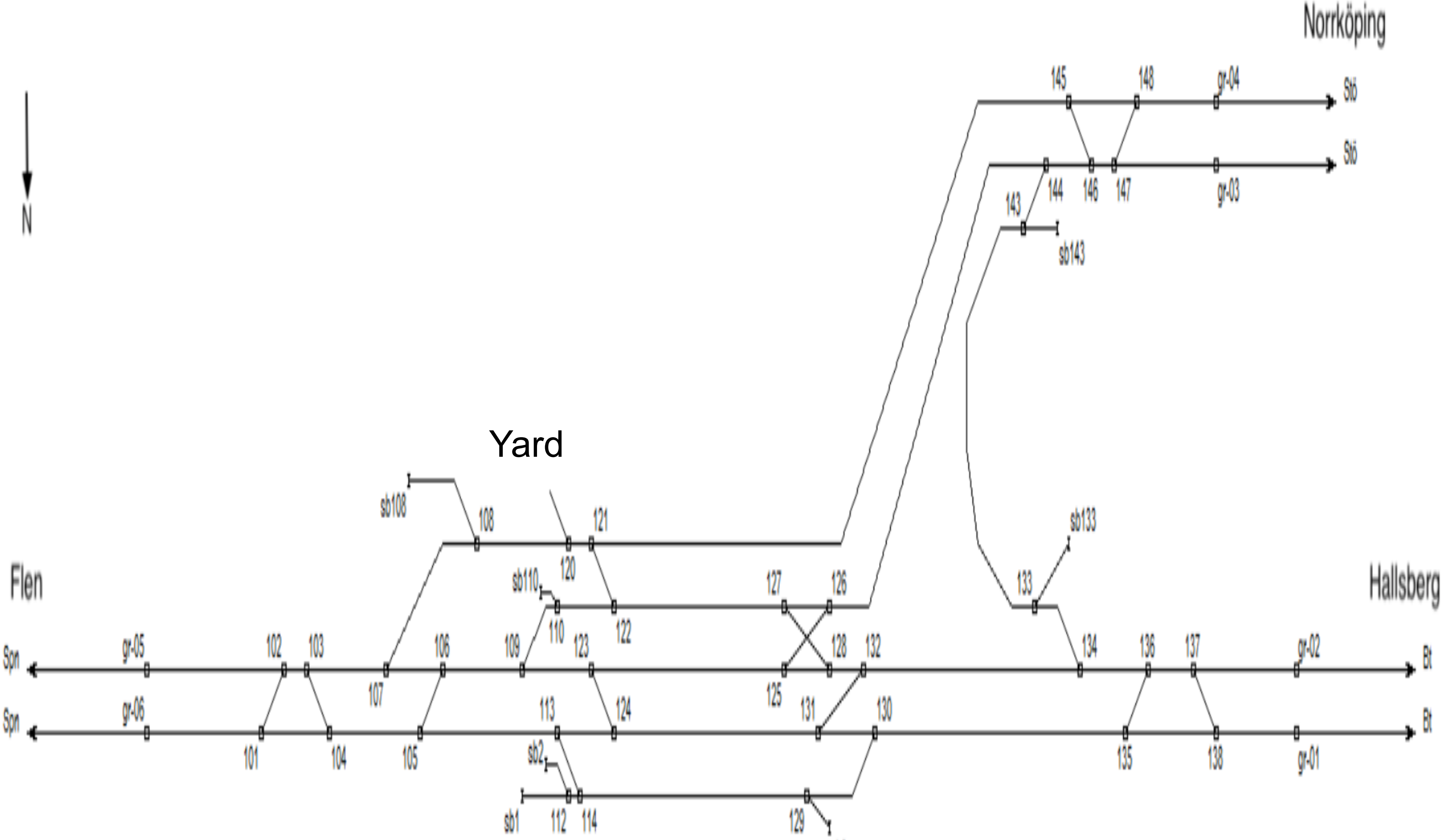


Reduced railway infrastructure – Just simultaneous relations



Result: 15 switches are kept, 16 switches are removed.

What if the overtaking relations are considered?



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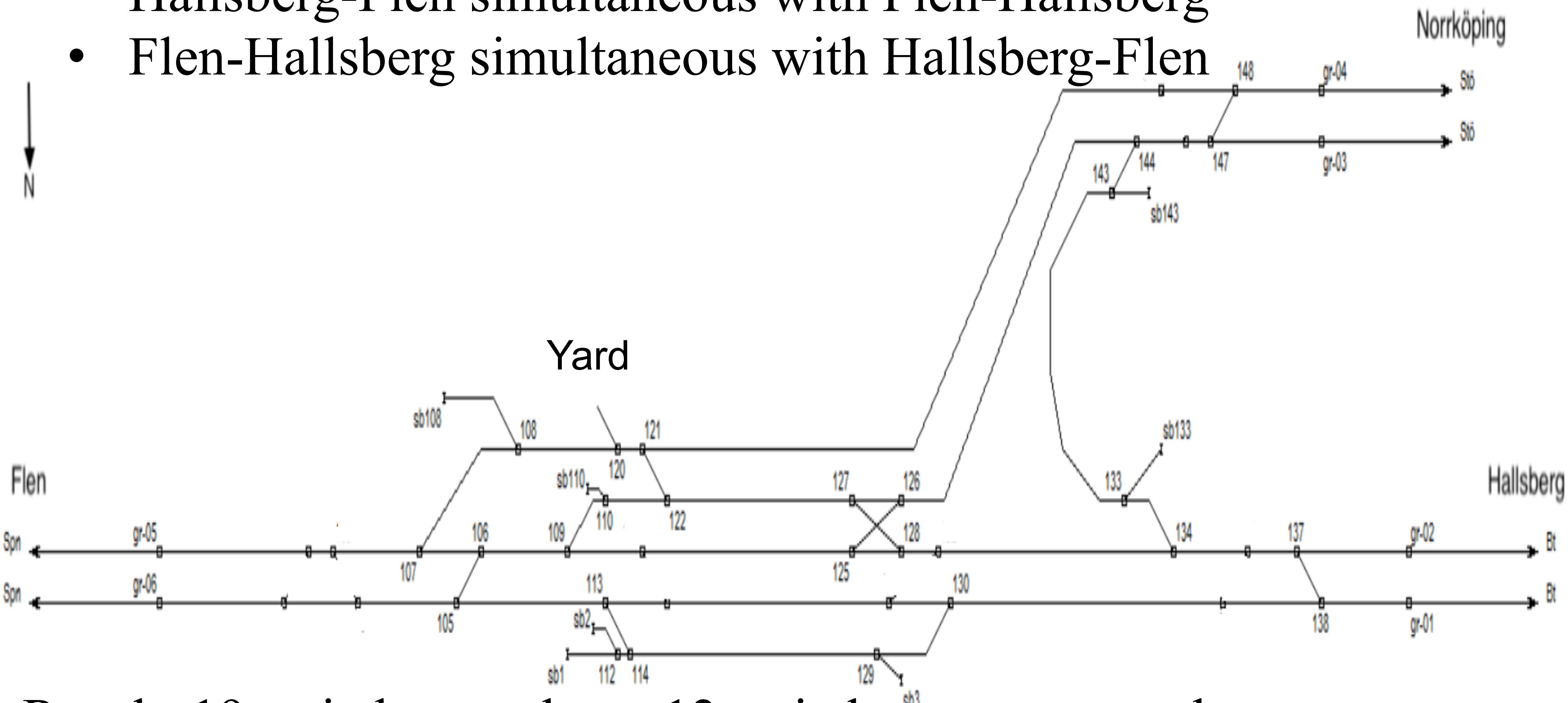
Four overtaking relations:

- Norrköping-Flen simultaneous with Flen-Norrköping
- Flen-Norrköping
- Hallsberg-Flen simultaneous with Flen-Hallsberg
- Flen-Hallsberg simultaneous with Hallsberg-Flen



Result: 19 switches are kept, 12 switches are removed.

Summary

- Model implemented in AMPL
- Applied to some experimental railway networks and Katrineholm station
- Need to visualize the solutions and more tests for the verification
- Single track on connecting lines
- Consider alternative formulations
- Next study will include shunting movements

Thanks for listening!
Questions?