

# Increasing the capacity by improving operational and tactical planning

Pavle Kecman

Anders Peterson

# Contents

- Introduction and motivation
- Stochastic railway traffic model
- Stochastic modelling of dispatching actions
- Application of the models (work in progress)

# Capacity4Rail WP3.2

- Simulation and models to evaluate enhanced capacity
- The aim of this task is to evaluate existing tools for their suitability to assess and improve capacity utilization

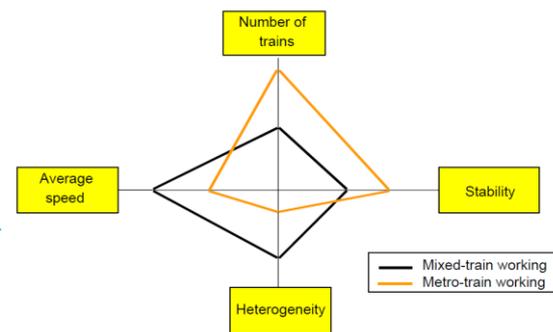
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- ”Capacity depends on the way it is utilised” (UIC 406)

# Capacity4Rail WP3.2

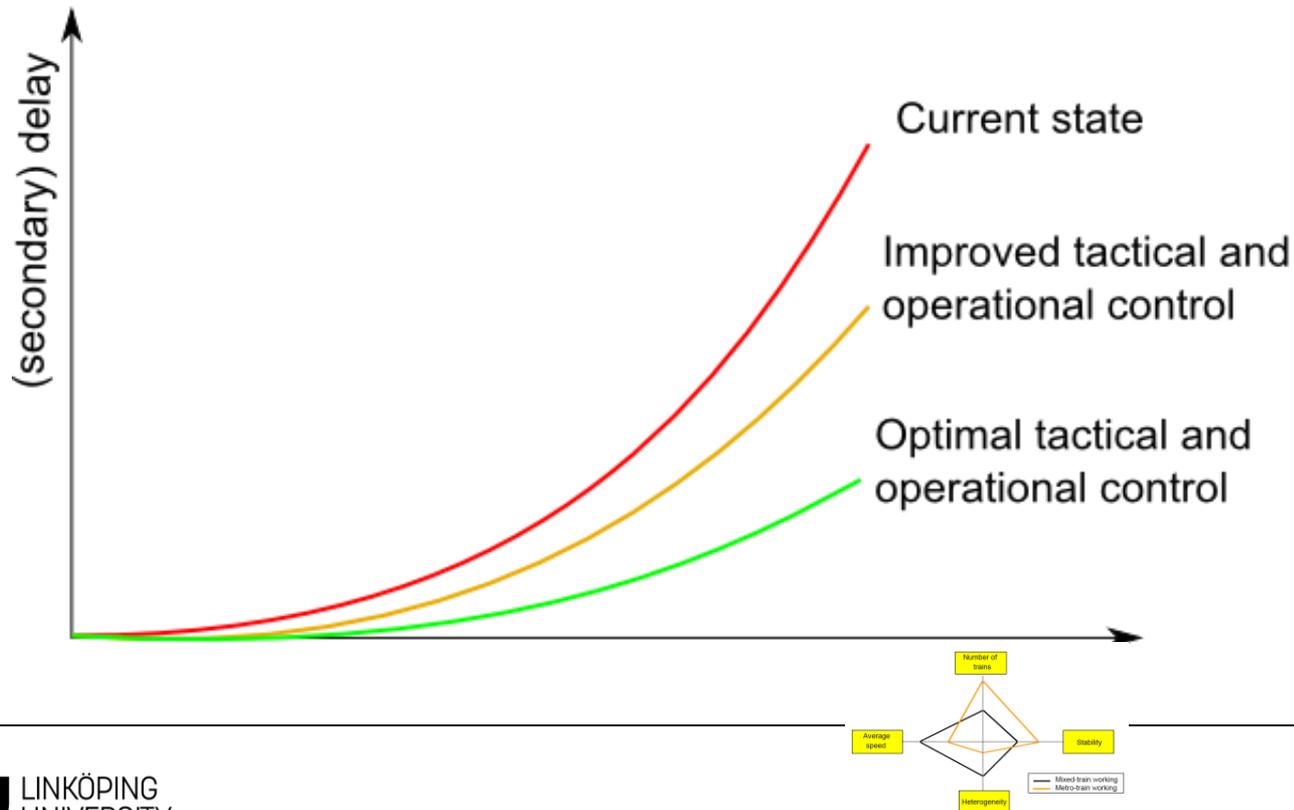
- Simulation and models to evaluate enhanced capacity
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- "Capacity depends on the way it is utilised" (UIC 406)
- Timetabling and traffic control determine the way capacity is utilised

Timetabling &  
Traffic control

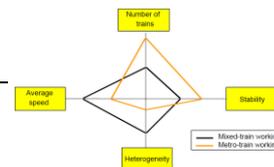
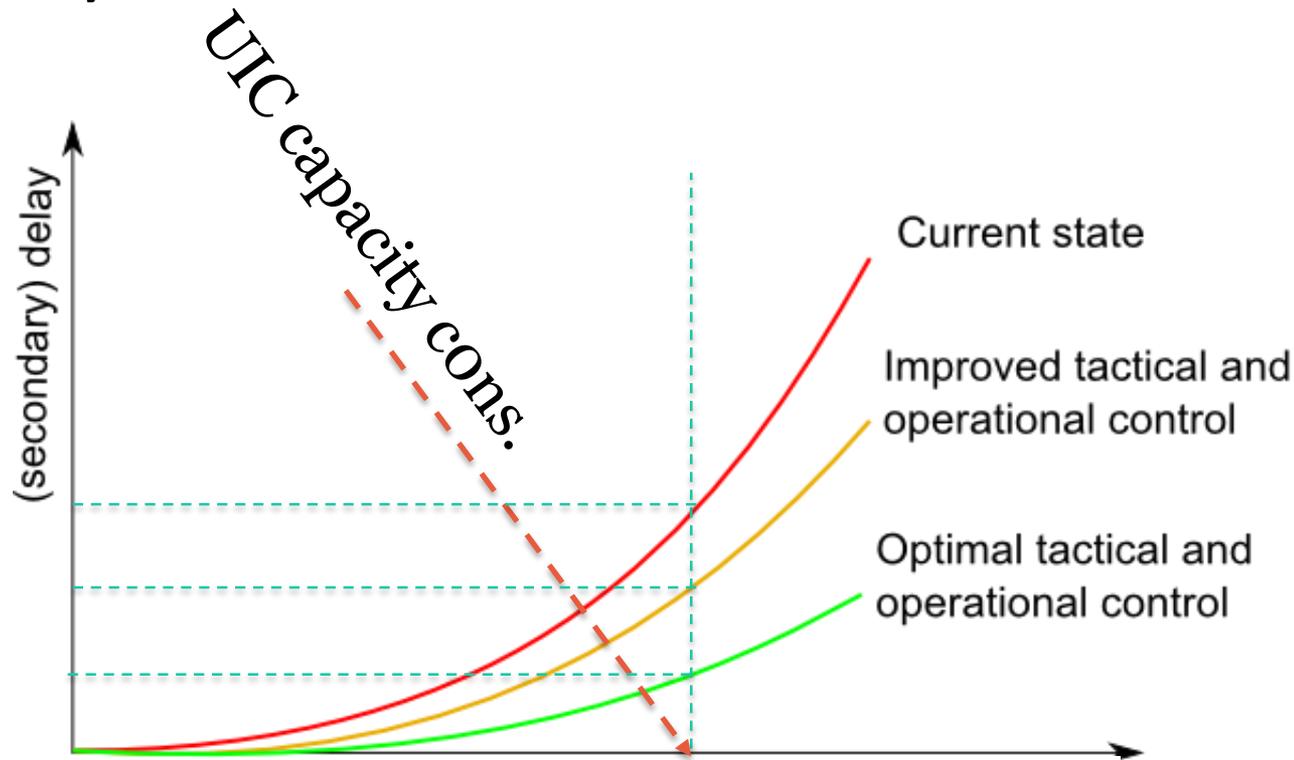


UIC 406

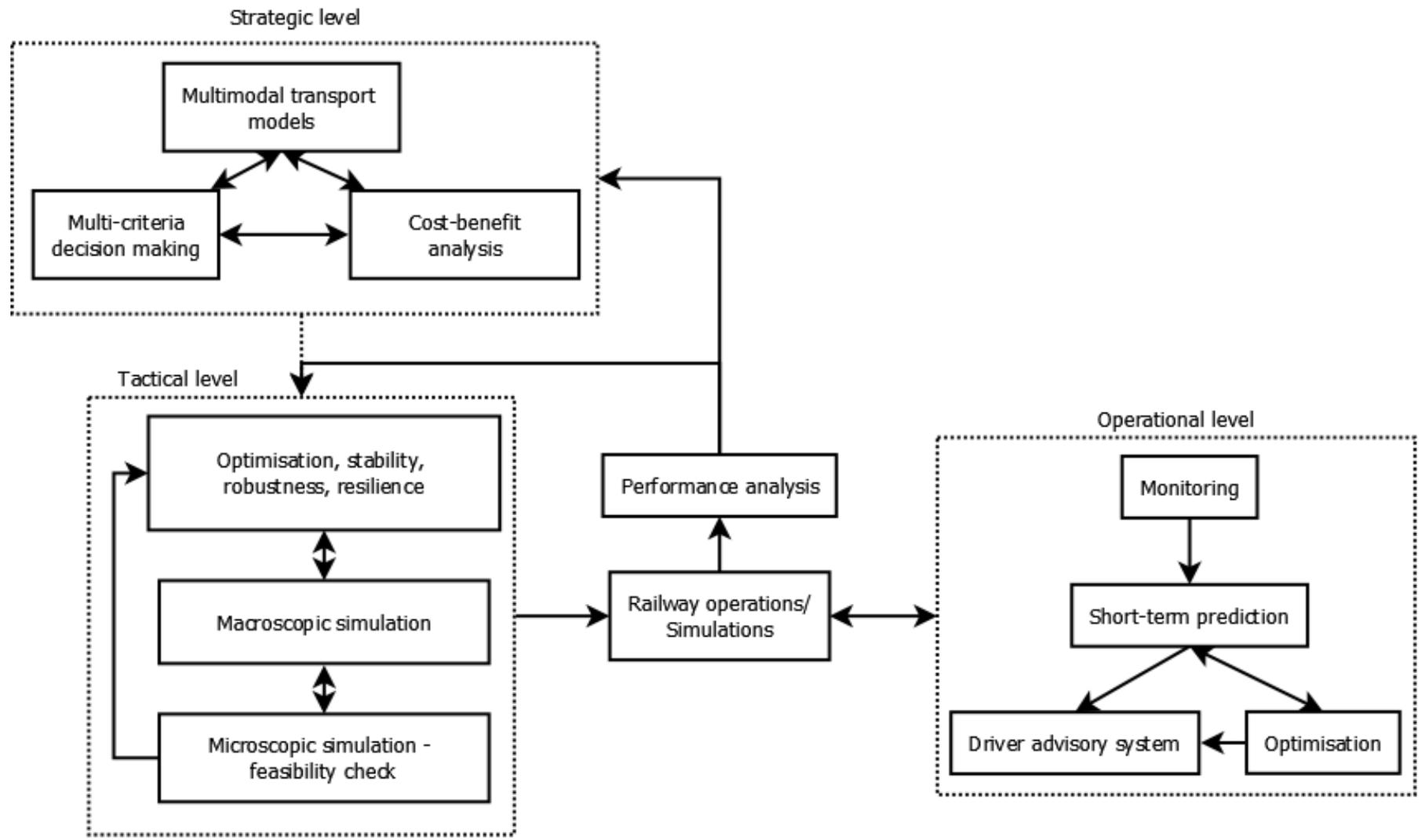
# Improved timetabling and traffic control enable more trains to run with the desired quality of service



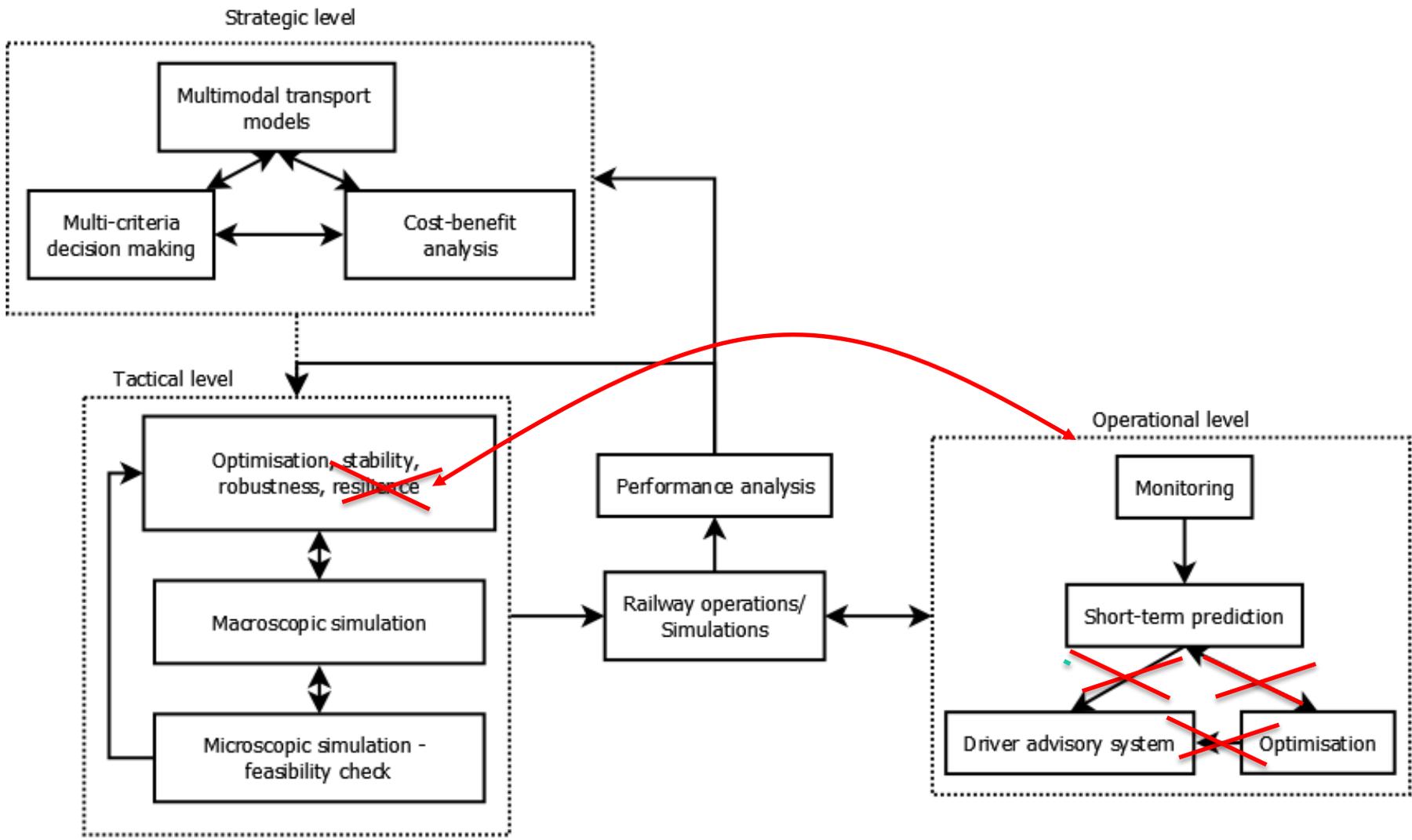
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# Modelling framework – ON TIME



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# Current SOTA in timetabling and traffic control

- **Traffic control**

- ✓ Optimisation models

- X **Deterministic** –  
assume full knowledge  
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- **Timetabling**

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- ✓ Robustness against  
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- X **Resilience** –  
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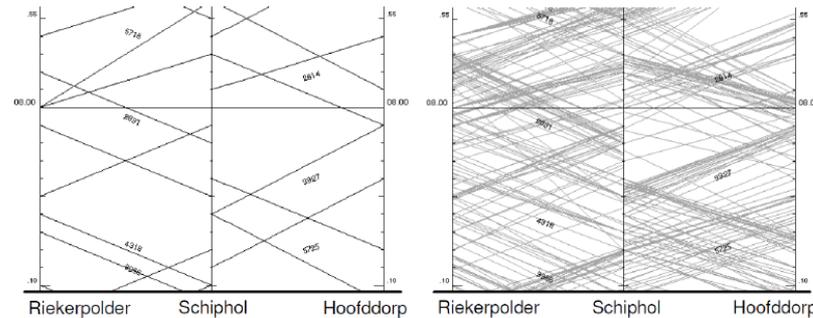
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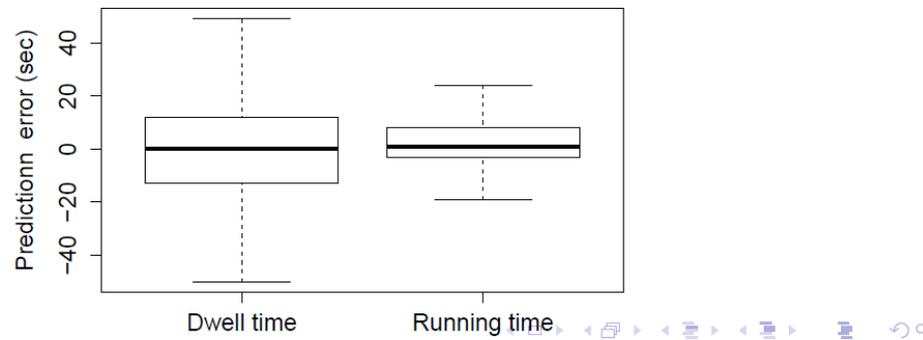
Stochastic prediction of  
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# Uncertainty in railway traffic

Railway traffic typically operates according to a timetable, however...

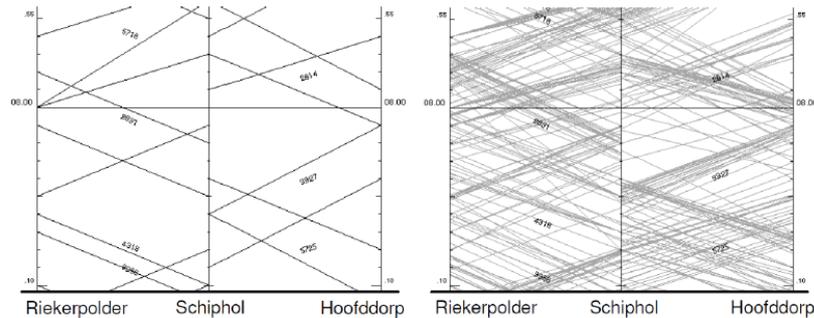


Source: D'Ariano, PhD thesis

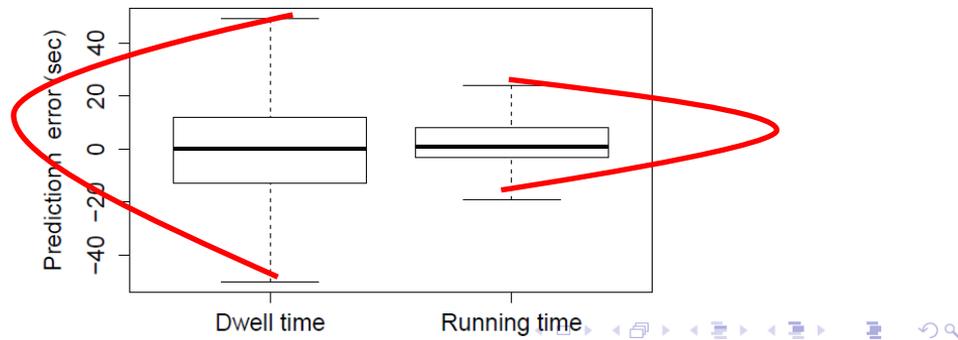


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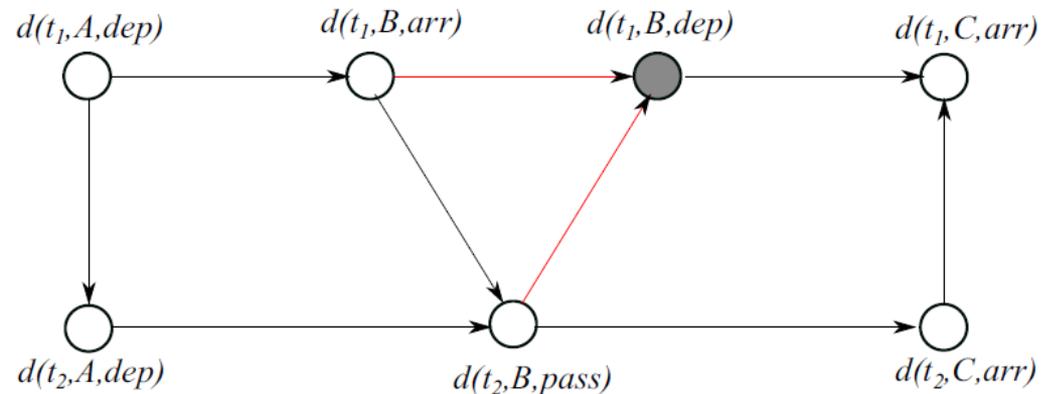
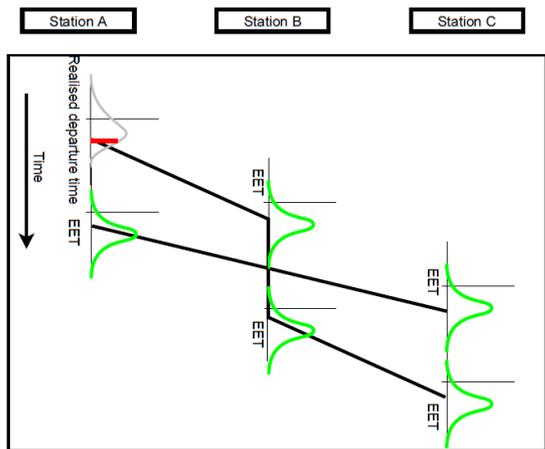


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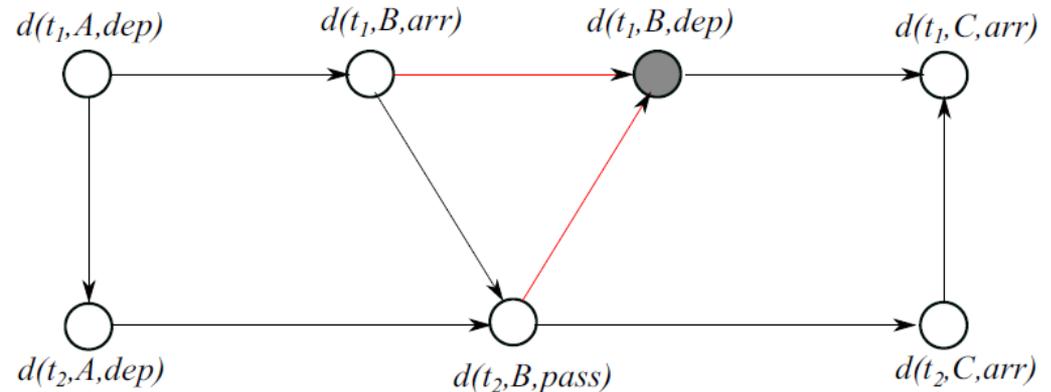
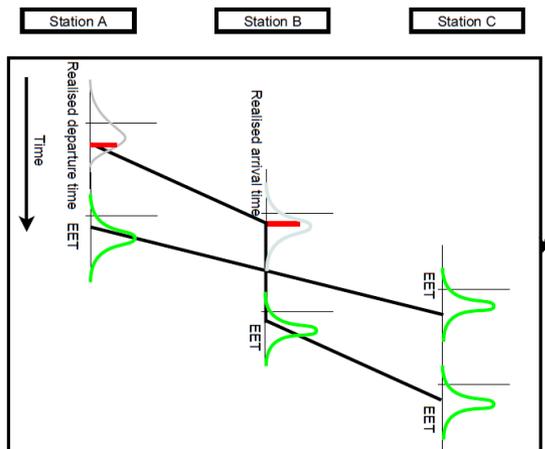
# Stochastic real-time traffic prediction

- Model is based on Bayesian networks (BN)
- Advanced data mining algorithms combined with the domain knowledge
- Accurate modelling of uncertainty under presence of real time information



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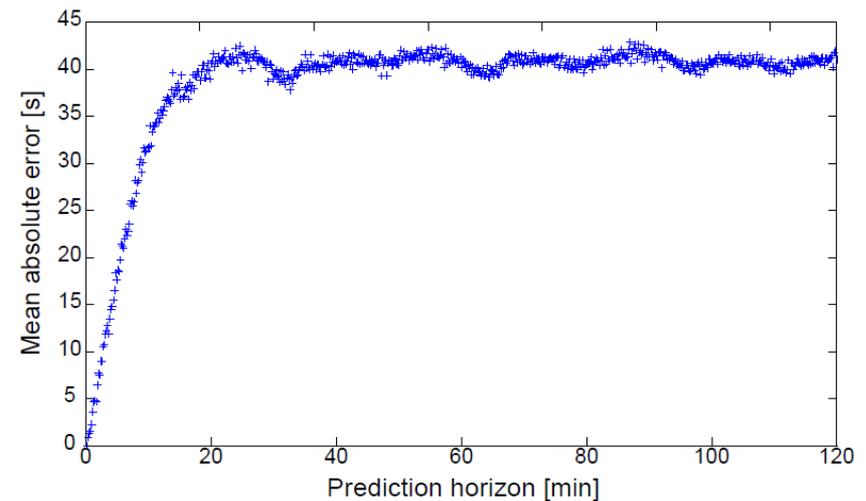
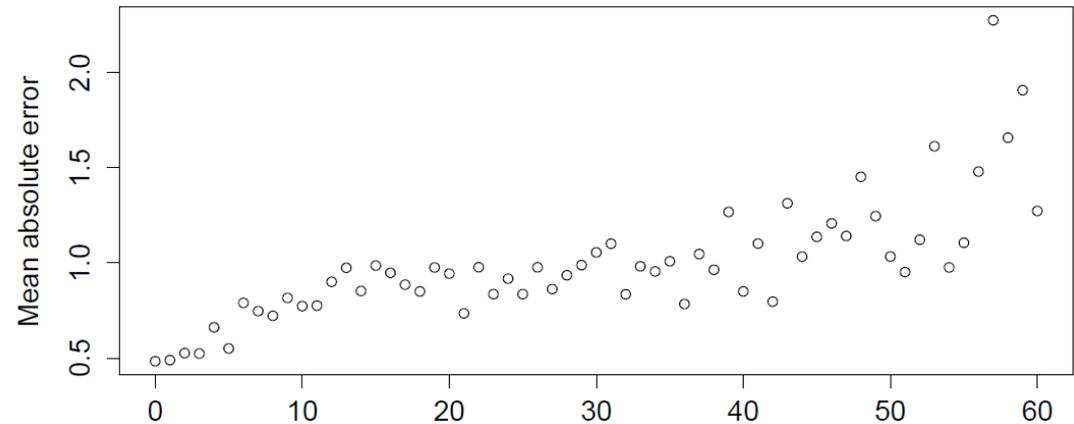


# Advantages of BN model

- Model gives accurate and stable predictions over long horizons
- Integration of historical data with real time information
- Probability of delay of all events is continuously updated as new information becomes available
- Distribution of a single, subset or complete set of events
- Most probable outcome

# Application of BN model

- Case study Stockholm - Norrköping
- Model trained with "Lupp" data
- Tested in a simulated real time environment
- Stable predictions within 1 min for 30 min ahead



# CASPT2015

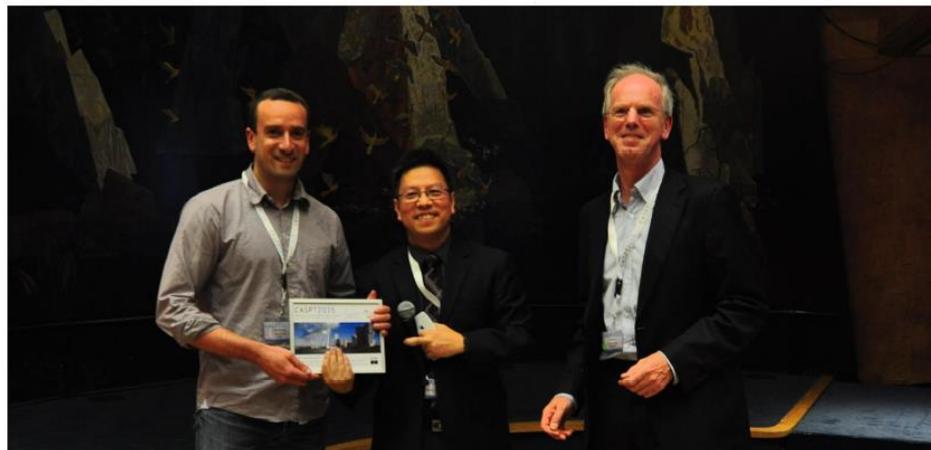
Conference on Advanced Systems in Public Transport  
July 19-23, 2015, Rotterdam, The Netherlands



## CASPT Best Paper Award:

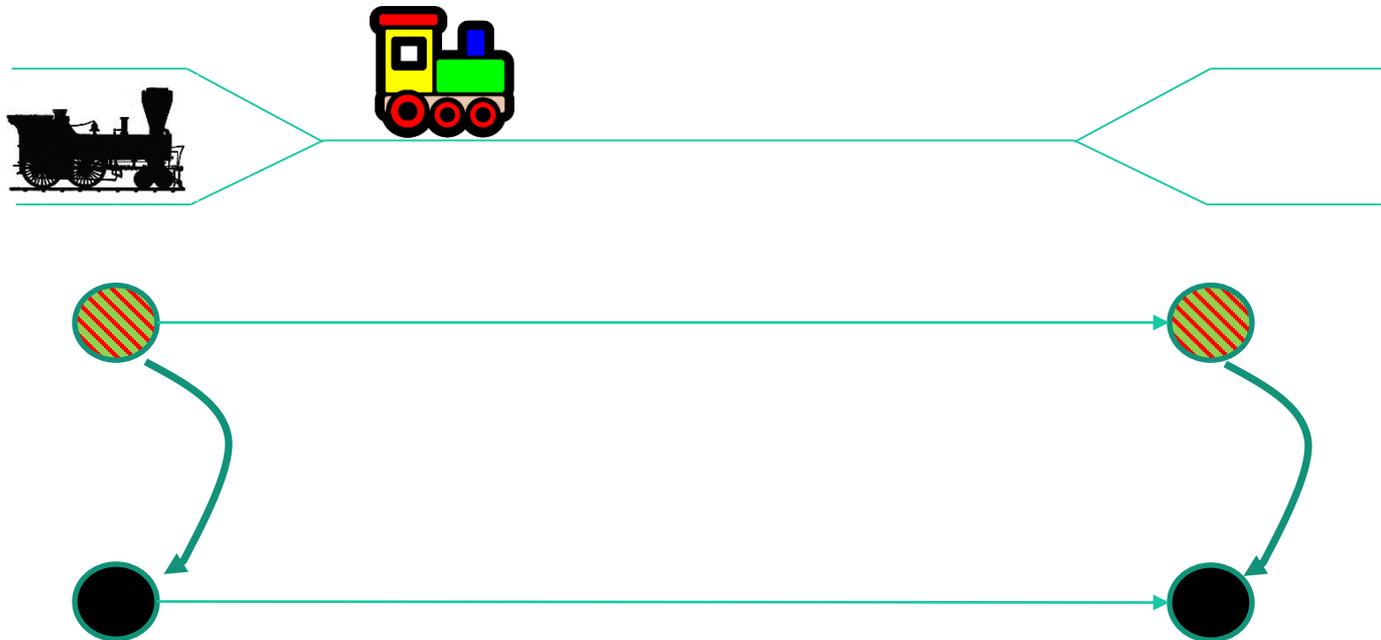
Stochastic Prediction of Train Delays in Real-time using Bayesian Networks  
*Pavle Kecman, Francesco Corman, Anders Peterson and Martin Joborn*

Sponsored by:



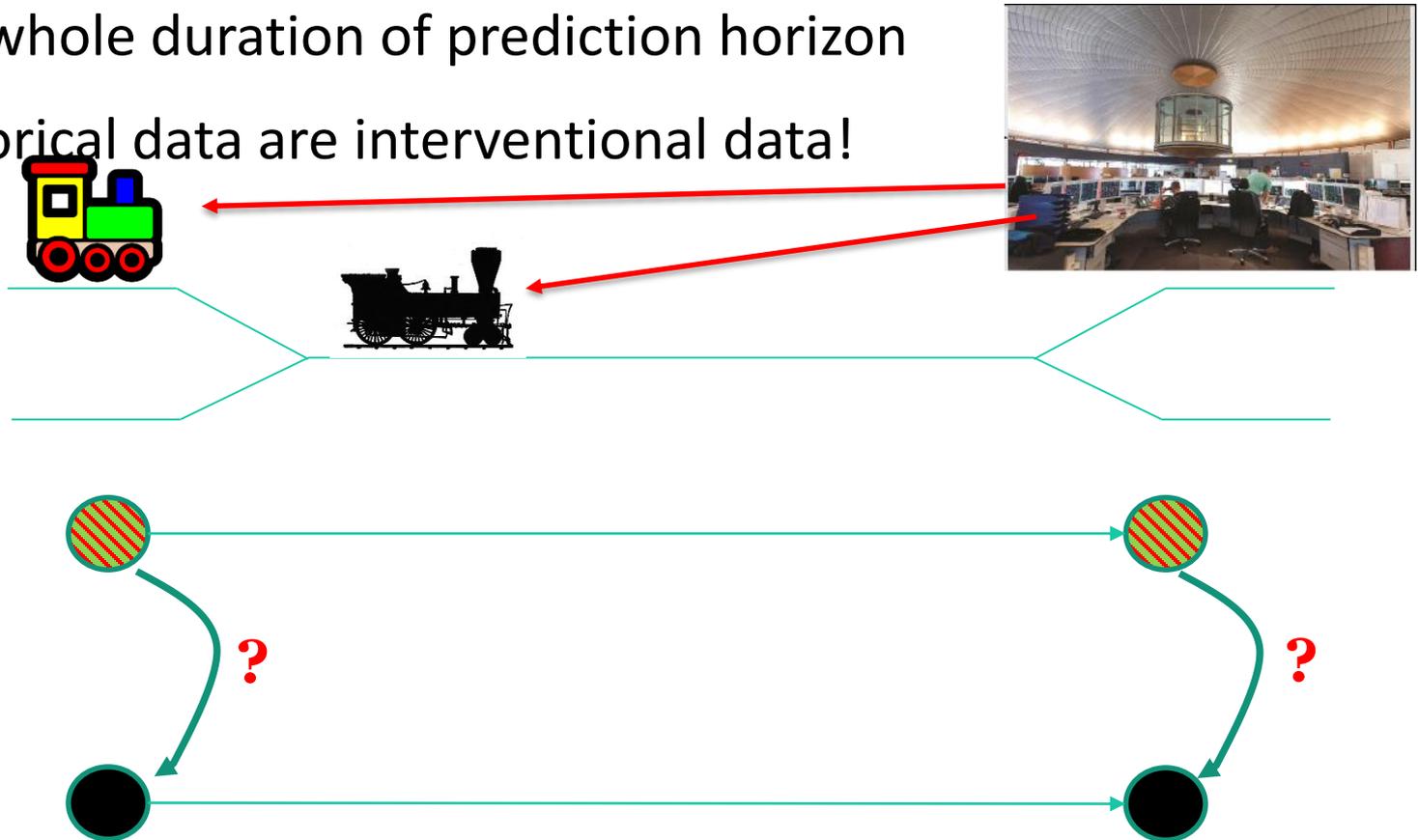
# Disdvantage of BN model ☹️

- Train routes and train orders are assumed to be known for the whole duration of prediction horizon
- Historical data are interventional data!



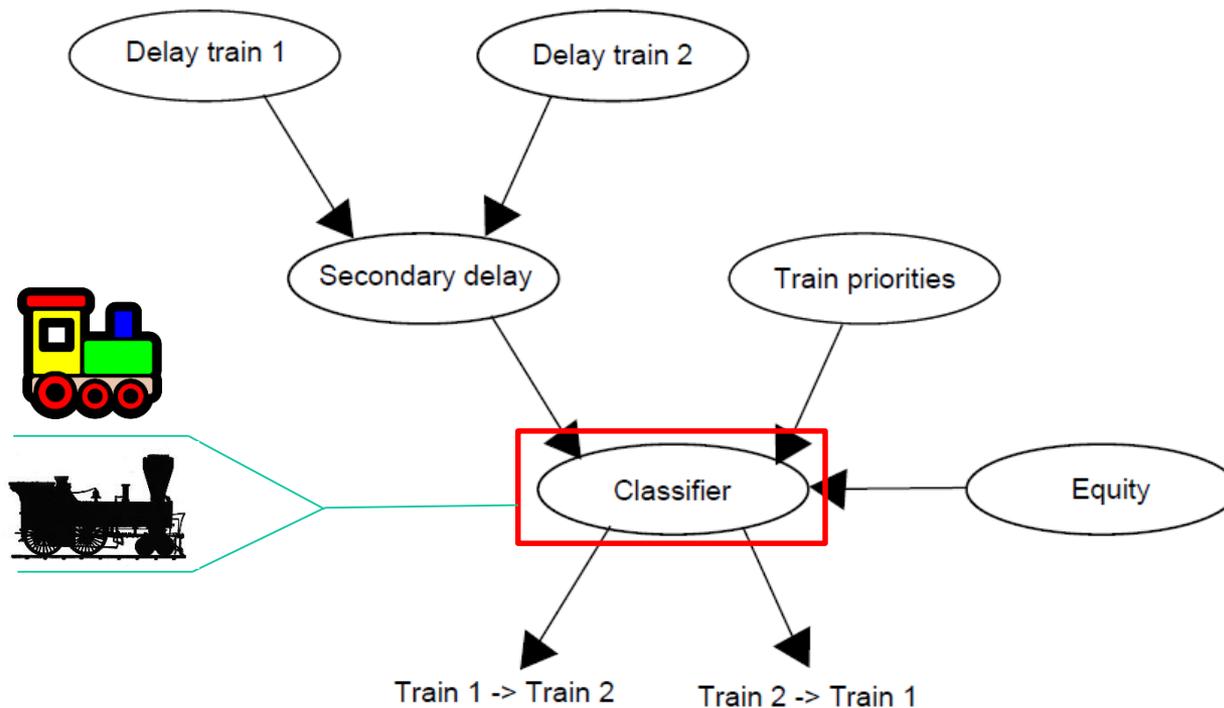
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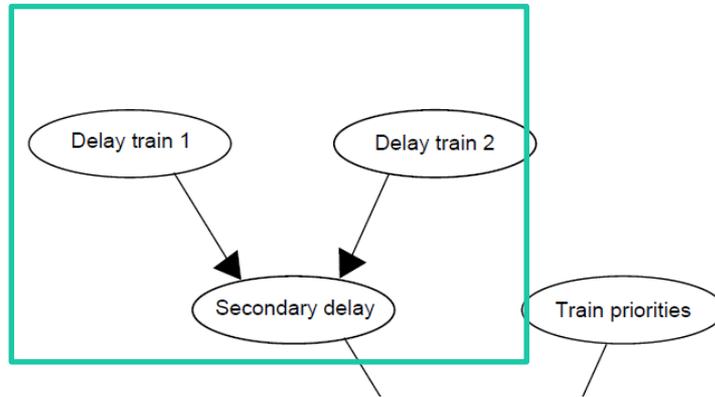


# Stochastic prediction of dispatching actions

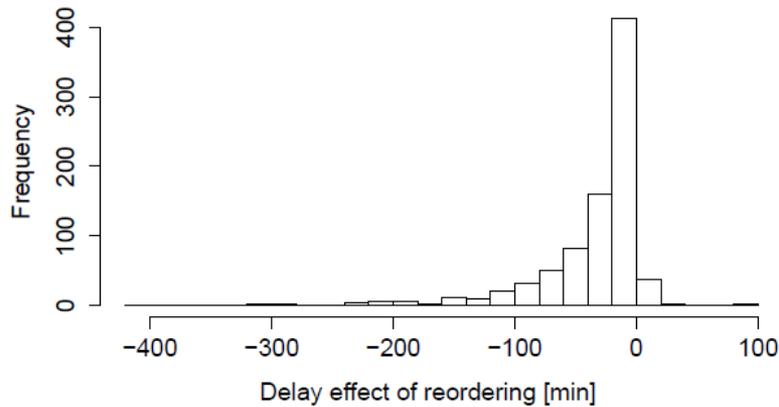
- Model based on Naive Bayesian classifier (NBC)



# Stochastic prediction of dispatching actions

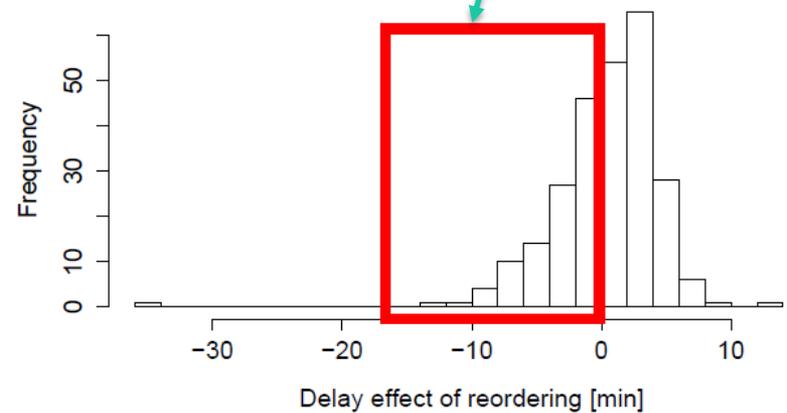


Changed order



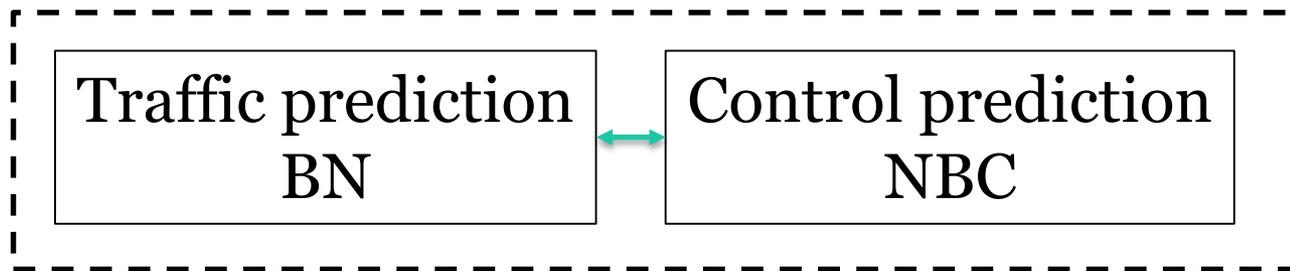
Wrong classification  
13%

No reordering



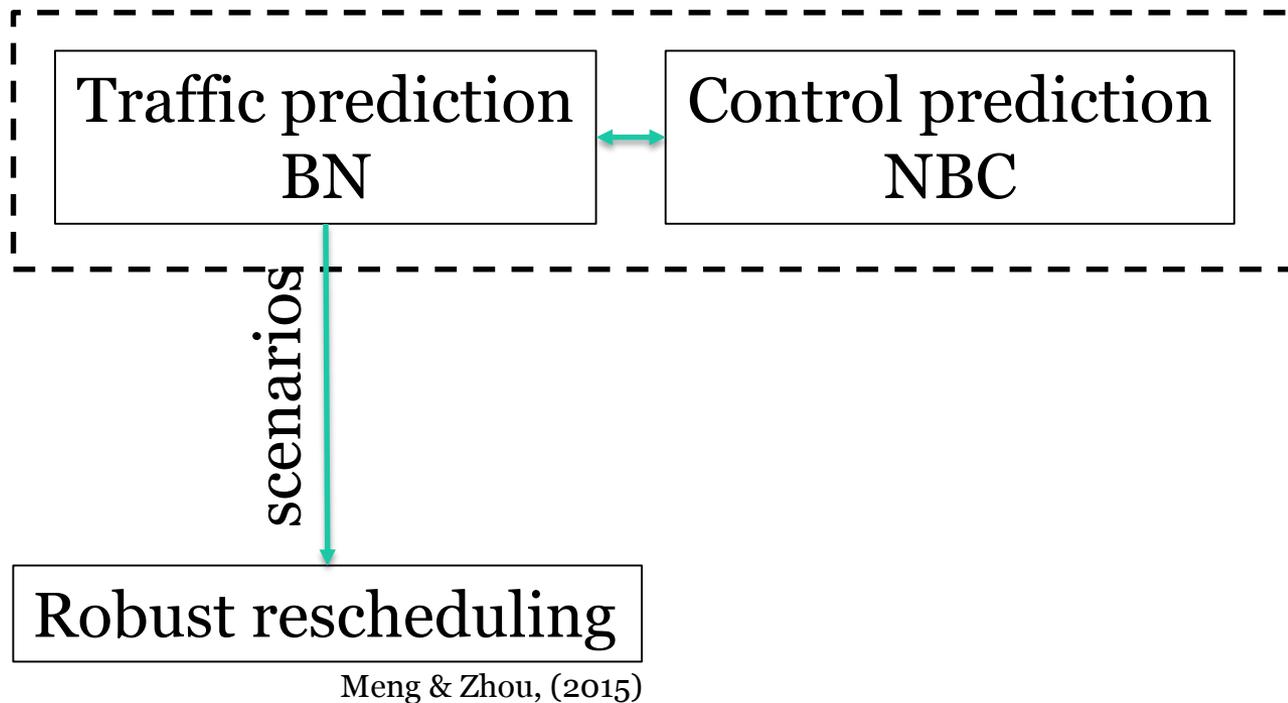
# Application of the models

Independent tool for traffic prediction and information

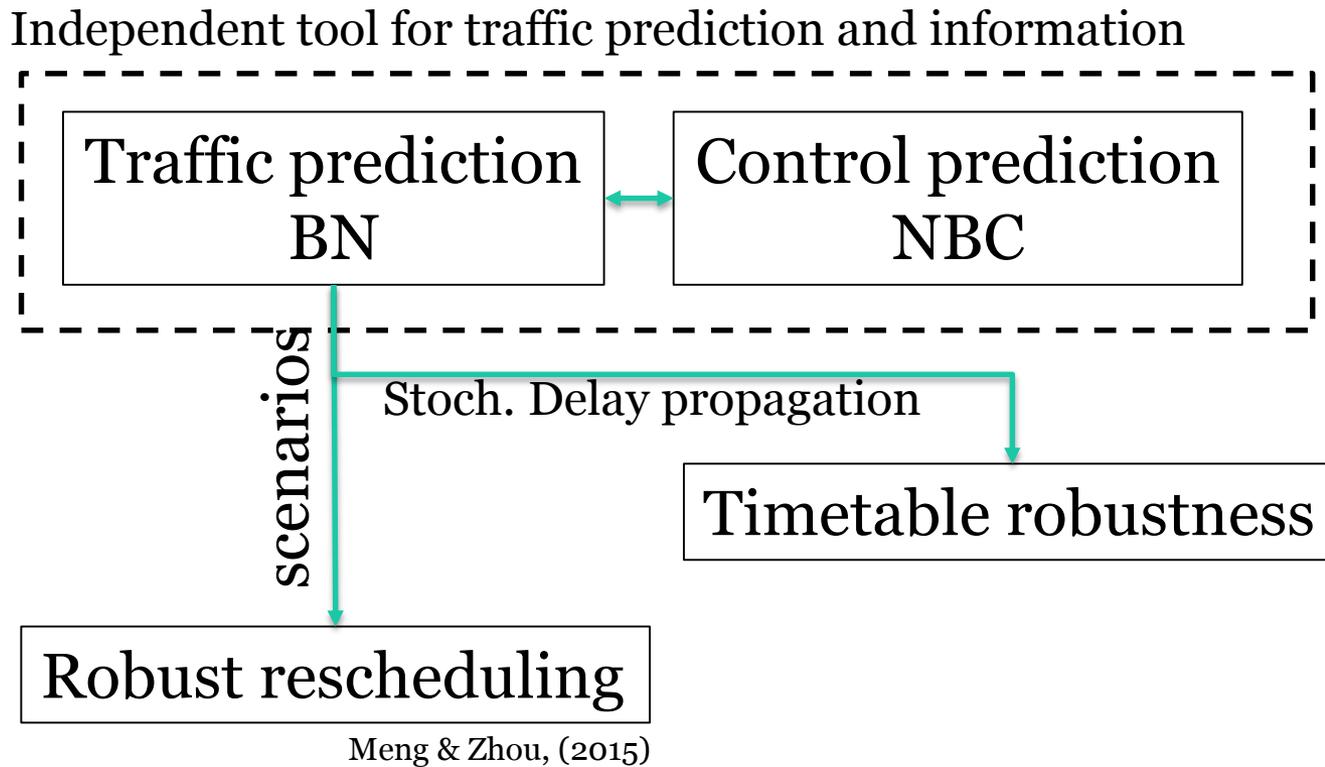


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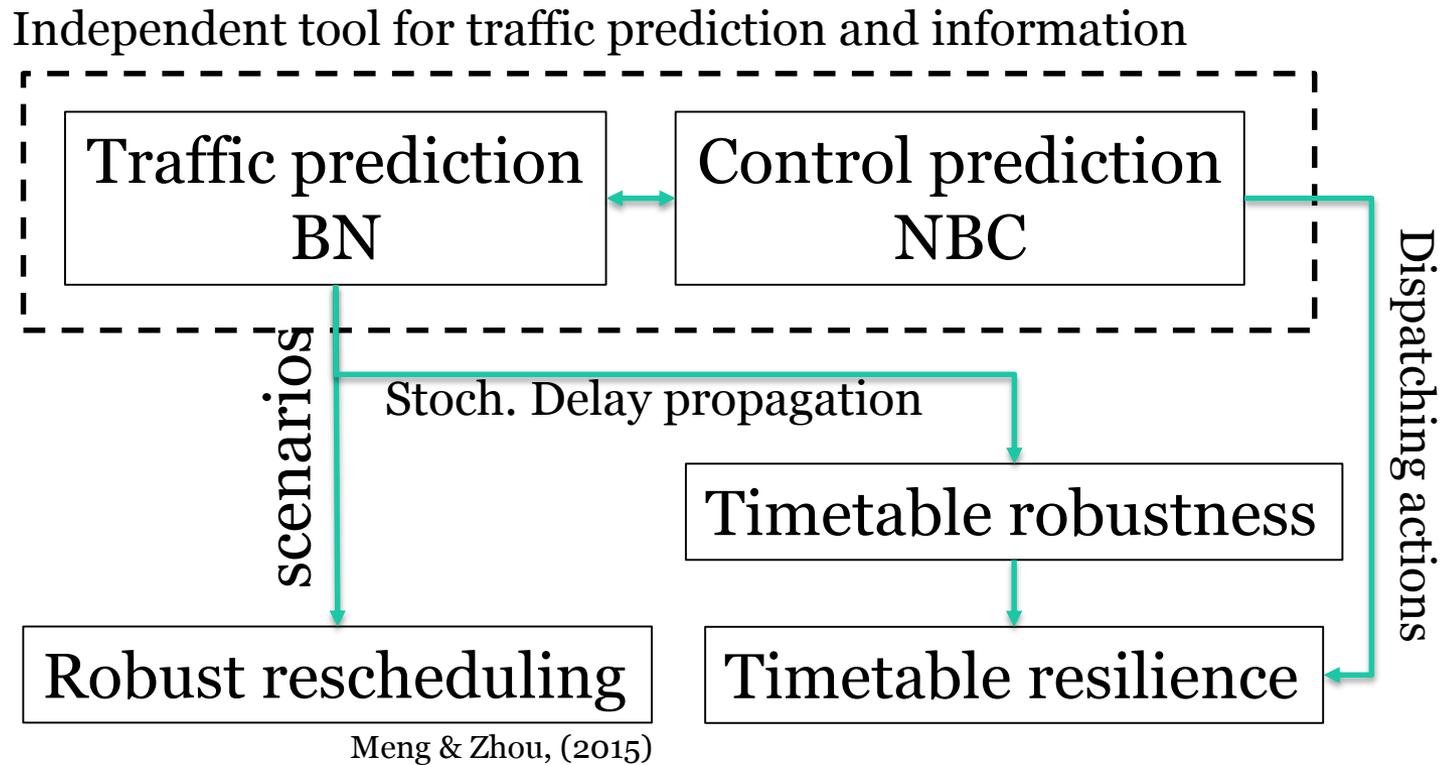
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# Application of the models



# Application of the models



# Next steps

- Integration of the Bayesian network model for real-time stochastic traffic prediction in a robust rescheduling framework
- Integration of Naive Bayesian classifier in a realistic timetable model for simultaneous testing of robustness and resilience
- Computing optimal robust and resilient timetables

Thank you for your attention

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