# Network-wide mixed-rail traffic scheduler: challenges and implementation aspects

**Karim Shahbaz, IIT Bombay**

***Collaborators:***

**Sidhartha I Kumar, Mitul Tyagi, S. P. Singh, S. V. Ramisetty, S. Pulapadi,**

**Madhu N. Belur, Narayan Rangaraj, Merajus Salekin, Raja Gopalakrishnan**

**Affiliations:**
Electrical Engineering department, IIT Bombay,
Industrial Engineering and Operations Research, IIT Bombay
Centre for Railway Information Systems, New Delhi

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# Objective

**Objective:**

Network-wide simulator/scheduler development for daily train timetable construction which is :

- Feasible (satisfying kinematic constraints).
- Conflict-free (satisfying time-complementing resource utilization and safety constraints).

# GQD Data: Routes Information SD

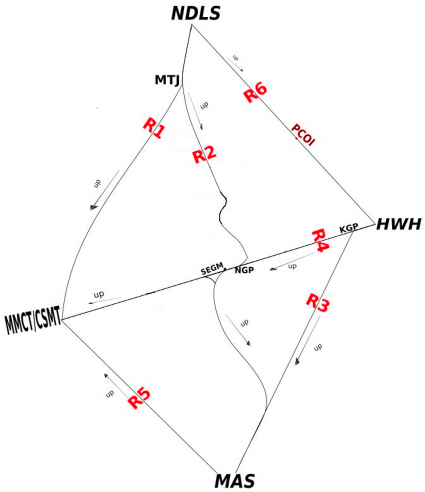


Figure: GQD route map

# Simulator: challenges

Should handle linear sections and/or networks with the same definition of inputs and outputs.

The simulator should be able to resolve cycles and handle route reversals.

The simulator should be able to handle the possibility of deadlock.

The simulator should be able to handle multiple zero mile-posts.

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# Single section scheduler: Kinematic constraints

Scheduling in long-distance networks with heterogeneous sets of trains with different kinematic capabilities and priority.

The type of coaches and their composition determines train kinematic characteristics (i.e., maximum speed, acceleration, deceleration, and length).

Infrastructure elements: maximum permissible speeds for different block sections and the current state on the multi-aspect signaling system.

The train schedule in a block section is influenced by limits of rolling stock, track, and signaling.

Allocation of the type of line determines the signal aspect and train entry speed at the stations.

# Single section scheduler: Simulation sequence

The simulator is serial. It uses travel-advance, greedy heuristics.

Trains are ordered as one list of trains to be simulated and paths are found.

## Sorting scheme

- Trains are sorted priority-wise and scheduled: higher priority trains get scheduled first.
- Among trains of the same priority starting earlier gets scheduled first.
- To break further ties first occured train gets scheduled first.

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# Network-wide scheduler: Internet traffic analogy

Multi-route railway infrastructure network is viewed as a computer network.

Each node in the computer network makes a local decision for each packet as per destination thereby forming a per-node lookup table.

In train simulation, the current node ID (block/loop number) is meta-data to query the lookup table for allocation.

For unambiguous route determination, a detailed look-up table is required. The simulator also works with ambiguous route-resolvers using the priority of links.

# Network-wide scheduler: Route-resolver

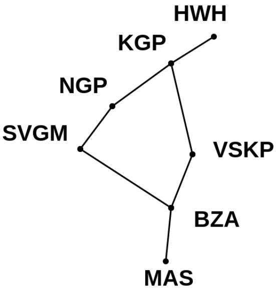

Figure: Multiple paths between an OD pair: route-resolver

The above figure shows two routes for the origin-destination pair.
Simulator (unlike the internet where only origin-destination matters), essentially should not suggest the next destination through a different route.

Simulator search space gets drastically reduced by route-resolver inclusion.

# Network-wide scheduler: Implementation

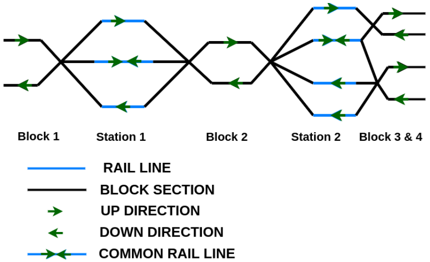


Figure: Linkage between running lines within stations and blocks

Our simulator relies on the linking description in the input file. It can model a non-linear network.

To reduce search space, the next link is explicitly specified whenever a route diverges.

For each train entry in an input file, a field containing a route map is added.

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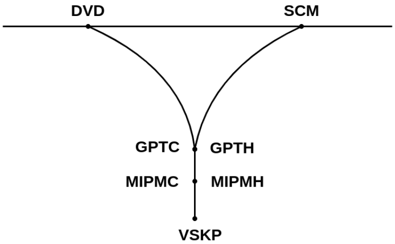
# Connected trains: Linking trains

Linking of trains running on multiple routes and reversals.
A long journey is broken into sub-journeys and linked to handle it.

Apart from single-section linking of departure time with arrival time as per halt duration, here route change and reversals are considered.

In low volume, rail traffic networks need not be modeled. The train is considered to rejoin the network based on the end-timing of the first part plus unmodelled part traversal time as the start-timing of the next part of the journey.



# Connected trains: train reversals

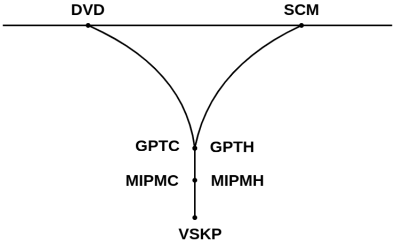


Figure: Connecting/Linking trains

The above figure shows train reversal at VSKP. GPT and MIPM are visited twice.

The journey to and from VSKP is split and appropriately linked with timings.

The simulator have two distinct simulations with matched timing for up and down traversal.

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# Conclusion

Methods to have a network-wide scheduler/simulator for mixed-rail traffic are described.

Various challenges in a network-wide simulation are explained such as being able to use the same infrastructure data in hybrid mode, scheduling involving reversals, change across routes, and discontinuities in the route.

Using the Golden Quadrilateral and Diagonal sub-network of Indian Railways, challenges were successfully overcome and implemented.

# Future directions

Systematic optimization of the timetable w.r.t. various performance metrics like

- wide freight corridors
- high average speeds across all trains
- other similar passenger-oriented performance measures

# Network-wide mixed-rail traffic scheduler: challenges and implementation aspects

*Thanks on behalf of IIT Bombay & CRIS*

*Any questions?*

*For more information contact us at the following:*
*karimshahee@ee.iitb.ac.in, belur@ee.iitb.ac.in, narayan.rangaraj@iitb.ac.in*