delaware

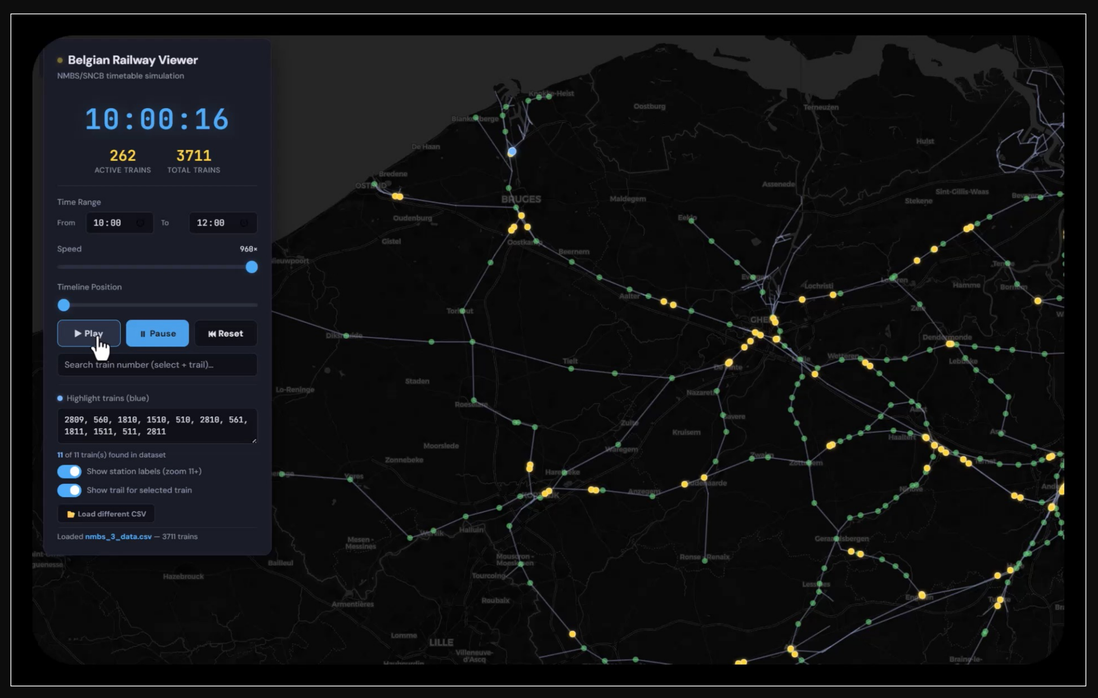
Aware to prepare. Prepared to decide.

BDO

NODE-EDGE NETWORK OPTIMISATIONS

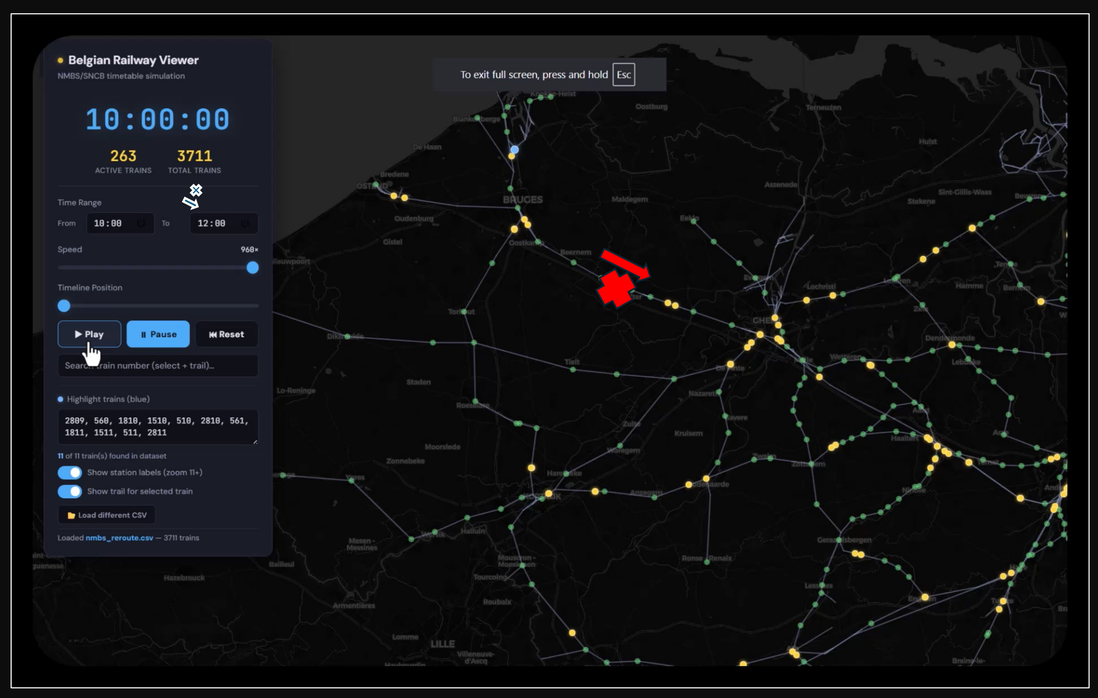
PRACTICAL CASE: QUANTUM-INSPIRED OPTIMISATION OF RAIL TRAFFIC AFTER DISRUPTION

Interactive Railway Traffic Map Normal Situation



Interactive visual of planned schedule 13/01/2026

Interactive Railway Traffic Map OPTIMAL Replanning



Disruption occurs at 10:00
Visual of the alternative routing/scheduling with minimal impact on overall delay

< 1 minute and Scalable

Objective: "Can a quantum enabled approach generate suggestions in less than a minute with the optimal re-routings, smart delays and with no or minimal cancellations?"

CASE DESCRIPTION AND SITUATION

Belgian railway infrastructure

- Passenger Trains: NMBS
- Freight Trains: Lineas, 14 others
- Orchestration: Infrabel
  - Mission: conflict-free operation

Planning

- All is known (weeks) upfront
  - Passenger: seasonal timetables
  - Freight: Reserved Rail tracks (with customer order planning)

Disruption response

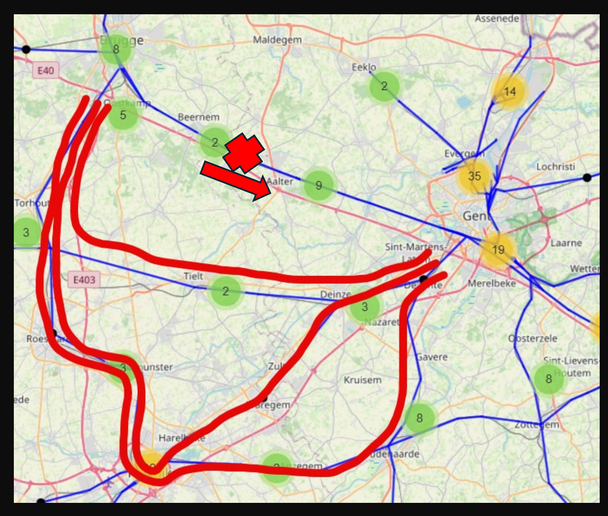
- Cancellations, Limitations
- Re-Routing, Alternative Routing

Theoretical 27 trains with each 11 possible alternative routes

Disruption leads to

27^{11} Train combinations

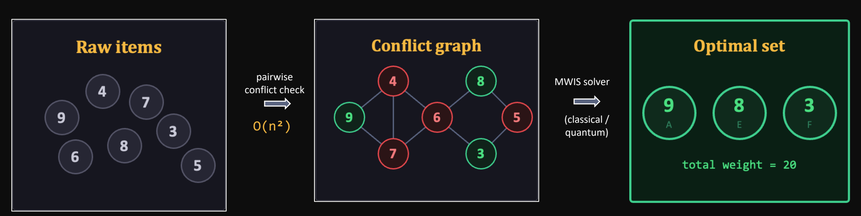
OBTAINED OPTIMAL ALTERNATIVE ROUTES AFTER PRE-PROCESSING



Two approaches for the combinatorial optimization

Brute force exhausts every possibility.	Maximum Weight Independent Set (MWIS) encodes the structure once — then exploits it.
BRUTE FORCE	**MWIS / CONFLICT GRAPH**
① **Enumerate all 2^n subsets** Every possible combination of items is listed.	① **Build conflict graph $O(n^2)$** One node per item. One edge per conflicting pair.
② **Validate each subset** For each subset, verify no two items conflict.	② **Assign weights to nodes** Each node inherits the item's value — done once.
③ **Track the best valid set** Keep a running maximum weight across all valid subsets.	③ **Solve MWIS on the graph** A specialised solver (classical or quantum) finds the optimal independent set.
Complexity: $O(2^n \times n)$ At n=50: ~10^{15} subsets. Infeasible without special hardware.	Complexity: $O(n^2)$ build + solver Graph build is cheap. Solver leverages structure — quantum excels here.

VS



Lessons learned

What actually determines whether a solver returns something a planner can use?

What we learned!

- Quality of the data and the rules
- Value comes from encoding and reformulating problems into rigorous structures, with decomposition/re-composition in mind. This way, complex problems can be solved today with classical and quantum-inspired solvers and later with quantum backends.

→ **Design towards a practical hybrid solution**

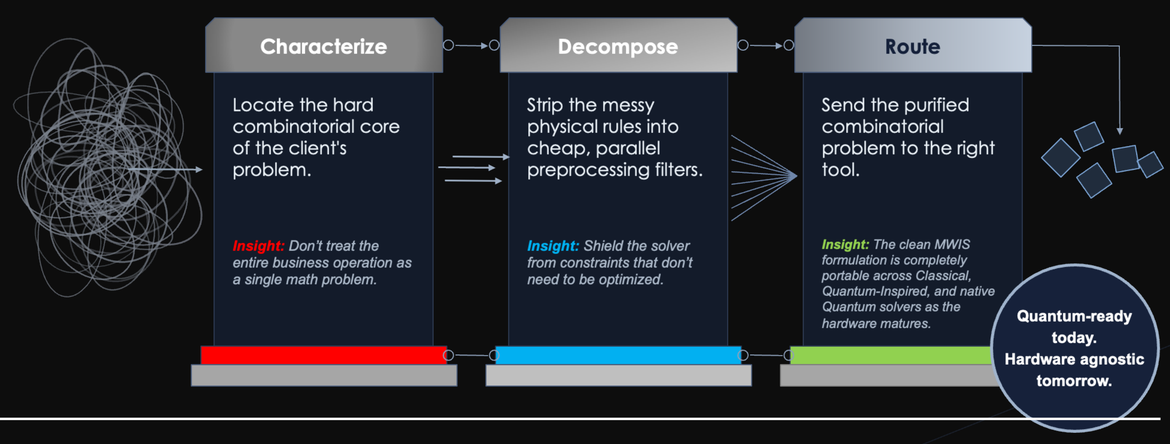
Can we…?

Construct an approach that offers workable options when small deviations hit an existing plan — a schedule, or the infrastructure itself?

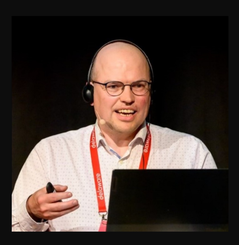
A disturbance. An emergency order. A blocked track.

… **yes, we can!**

The durable asset is the formulation knowledge, not the hardware.



delaware



Mark.Thienpont@delaware.pro
+32 473 79 07 48
AI & Quantum Lead Delaware (Belgium),
Maastricht University (The Netherlands)

quantum circle.eu



Walter.Vanherle@bdo.be
+32 497 59 62 26
Partner, BDO Digital
Innovation, Enabling and Emerging Technologies
Transport & Logistics

BDO