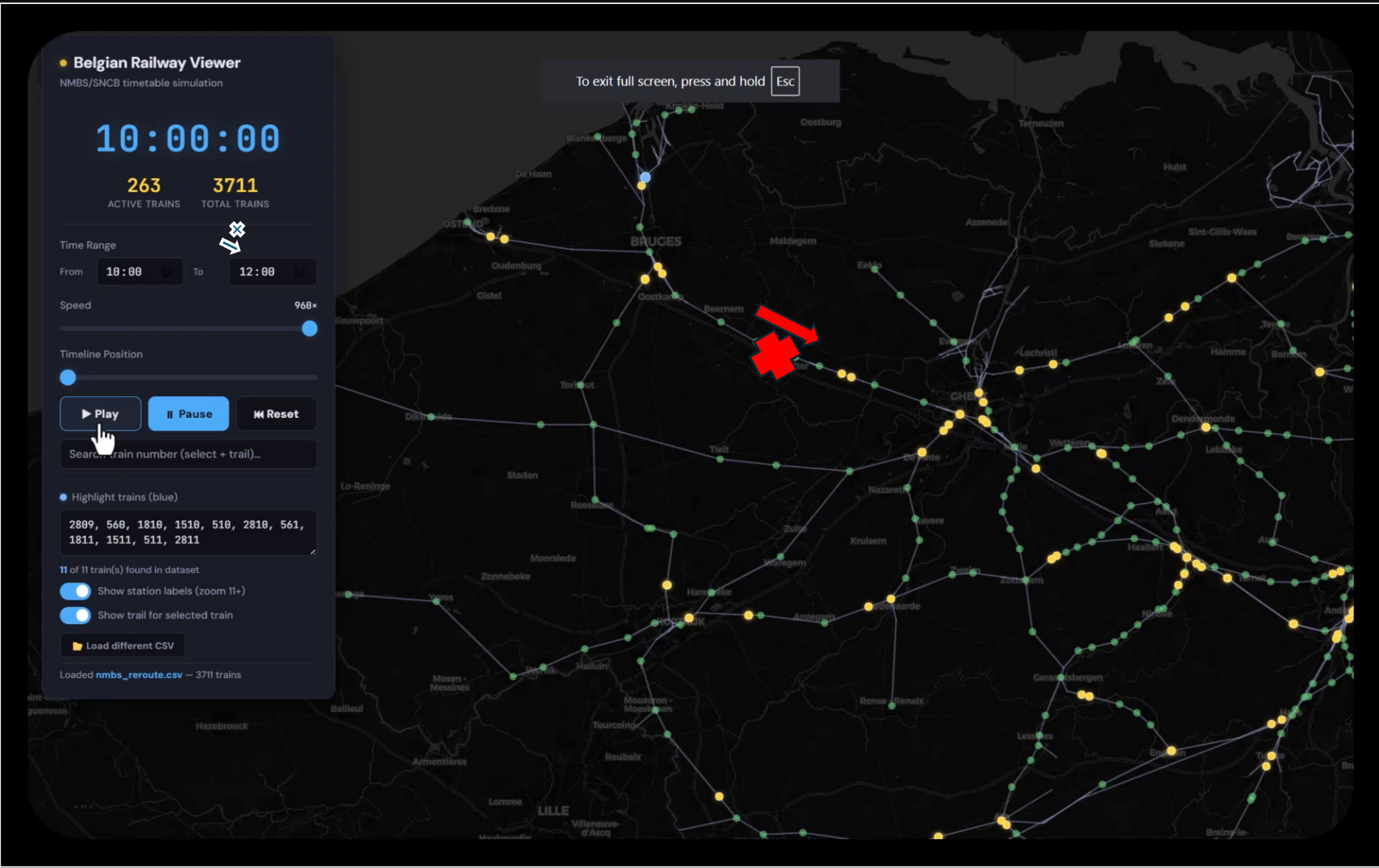
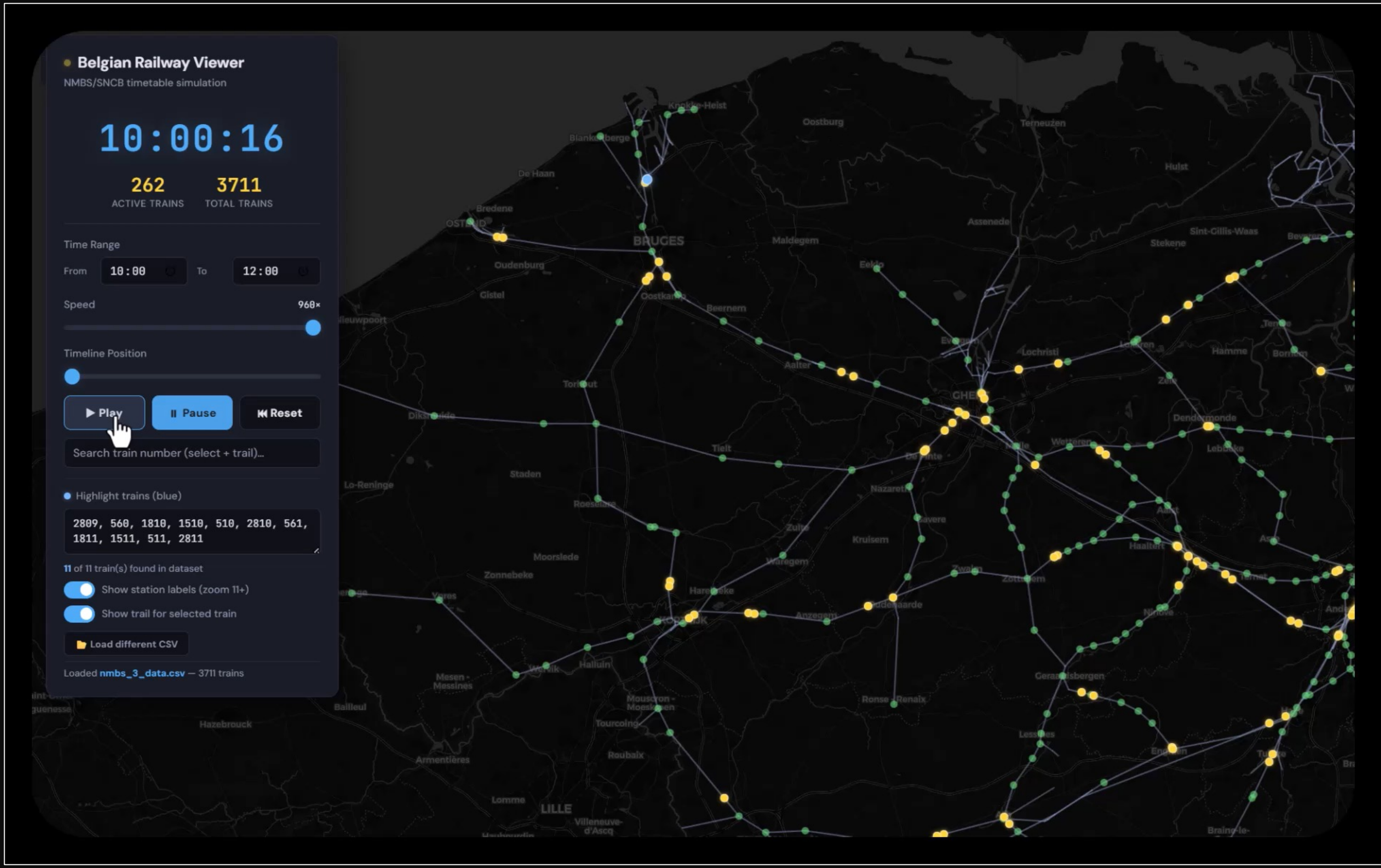


NODE-EDGE NETWORK OPTIMISATIONS

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

Interactive Railway Traffic Map **Normal** Situation

Interactive Railway Traffic Map **OPTIMAL** Replanning



Interactive visual of planned schedule 13/01/2026

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

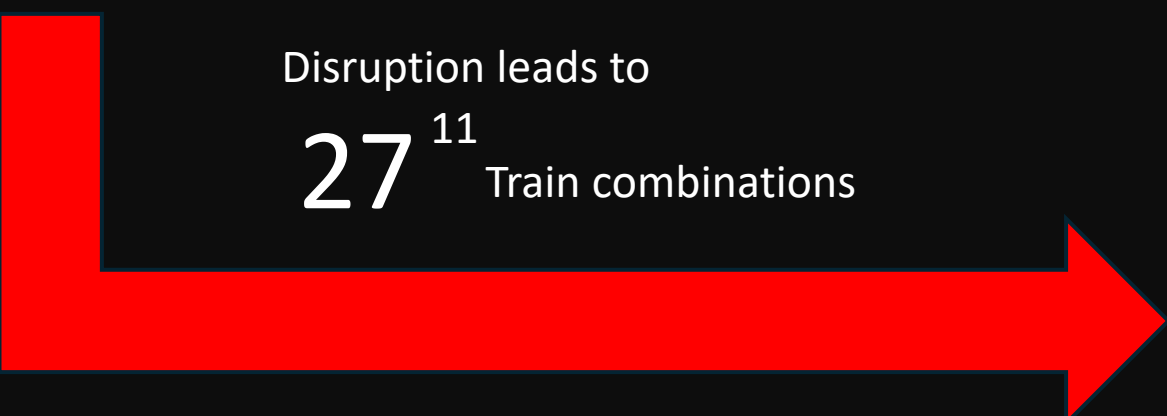
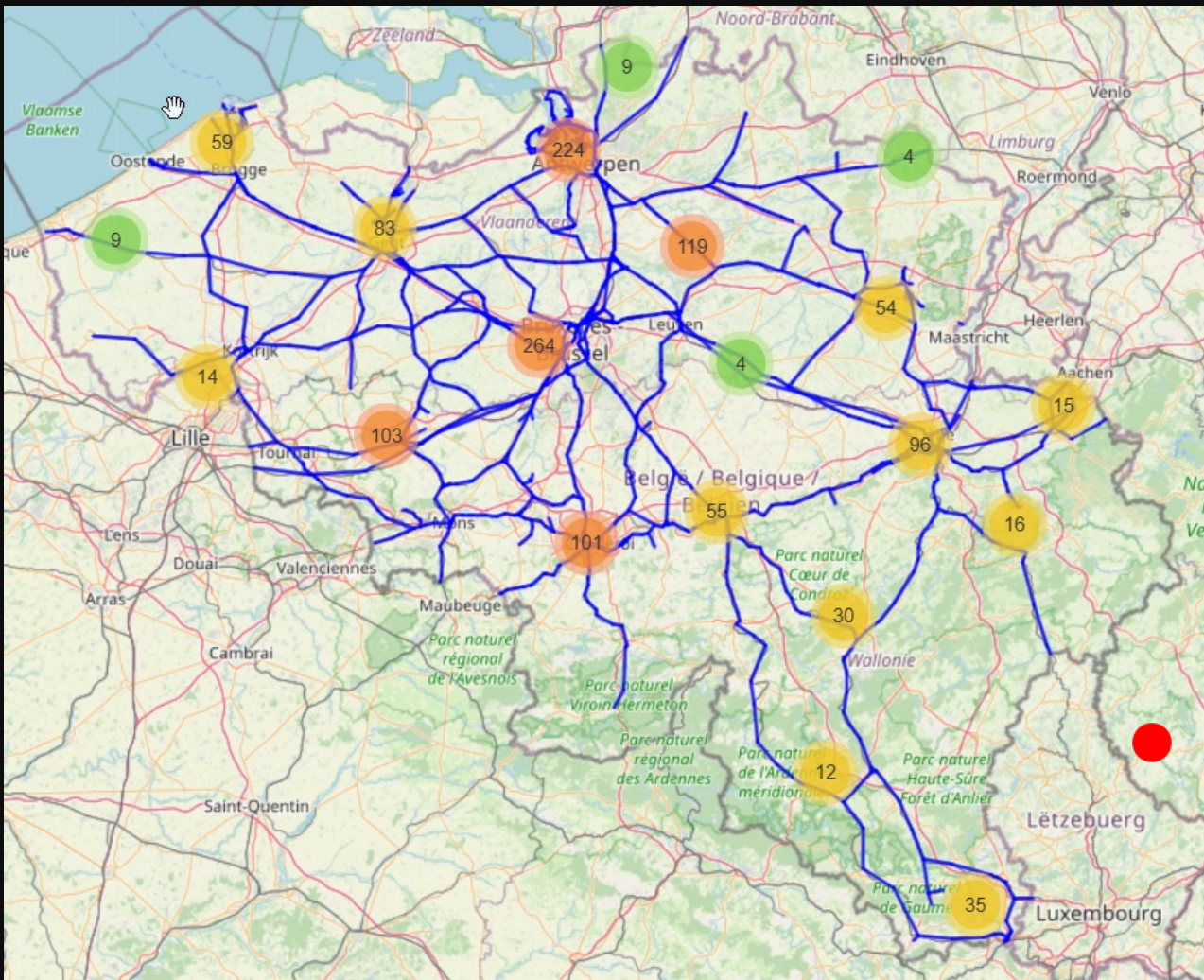
- Passenger Trains: NMBS
- Freight Trains: Linesas, 14 others
- Orchestration: Infrabel
- Mission: conflict-free operation

Planning

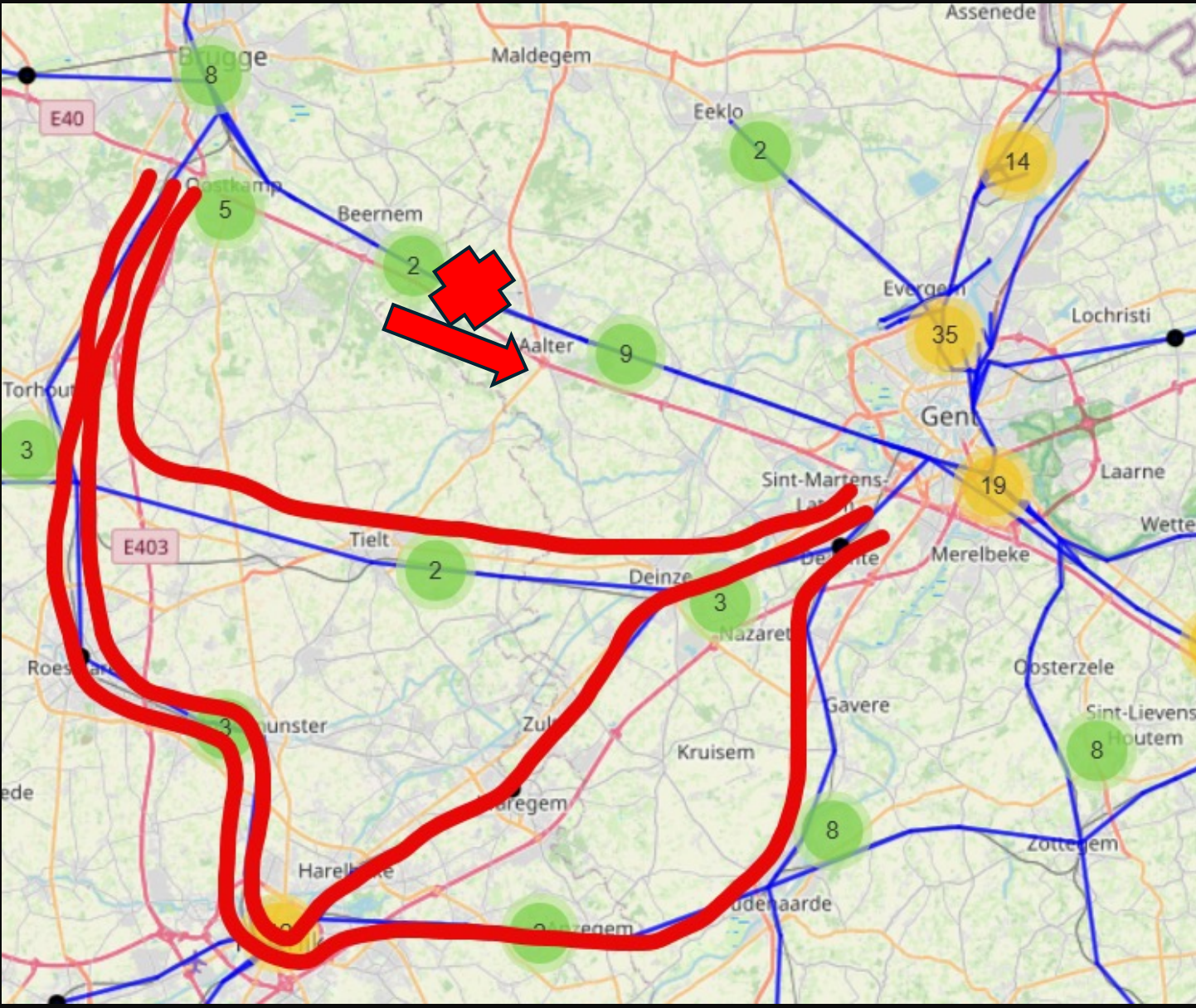
- All is known (weeks) upfront
- Passenger: seasonal timetables
- Freight: Reserved Rail tracks (with customer order planning)

Disruption response

- Cancellations, Limitations
- Re-Routing, Alternative Routing



OBTAINED OPTIMAL ALTERNATIVE ROUTES AFTER PRE-PROCESSING



Theoretical
27 trains with
each 11 possible
alternative
routes

Two approaches for the combinatorial optimization

Brute force exhausts every possibility.

BRUTE FORCE

- 1 **Enumerate all 2ⁿ subsets**
Every possible combination of items is listed.
- 2 **Validate each subset**
For each subset, verify no two items conflict.
- 3 **Track the best valid set**
Keep a running maximum weight across all valid subsets.

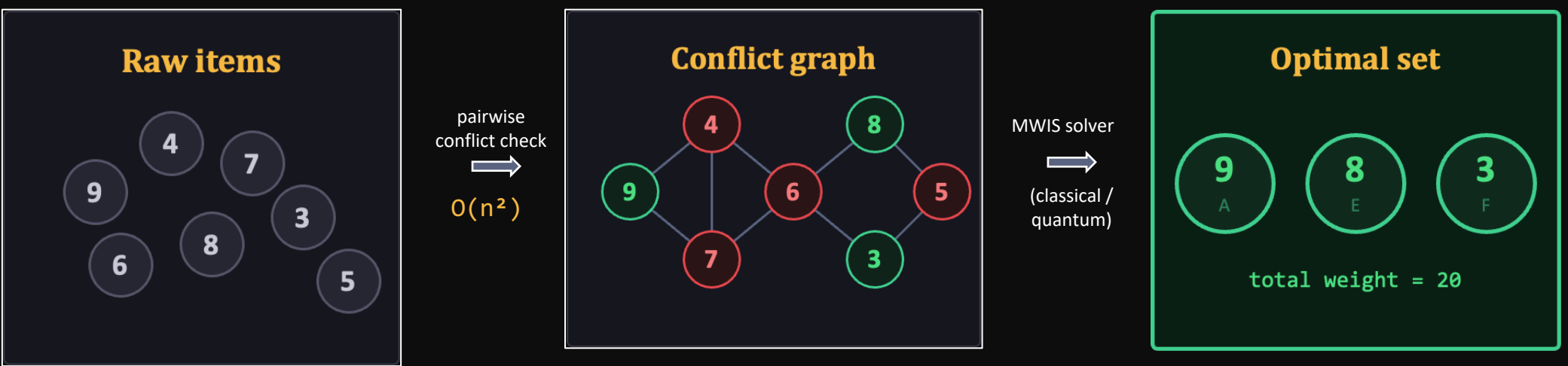
Complexity: $O(2^n \times n)$
At $n=50$: $\sim 10^{15}$ subsets. Infeasible without special hardware.

Maximum Weight Independent Set (MWIS) encodes the structure once — then exploits it.

MWIS / CONFLICT GRAPH

- 1 **Build conflict graph $O(n^2)$**
One node per item. One edge per conflicting pair.
- 2 **Assign weights to nodes**
Each node inherits the item's value — done once.
- 3 **Solve MWIS on the graph**
A specialised solver (classical or quantum) finds the optimal independent set.

Complexity: $O(n^2)$ **build + solver**
Graph build is cheap. Solver leverages structure — quantum excels here.



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**

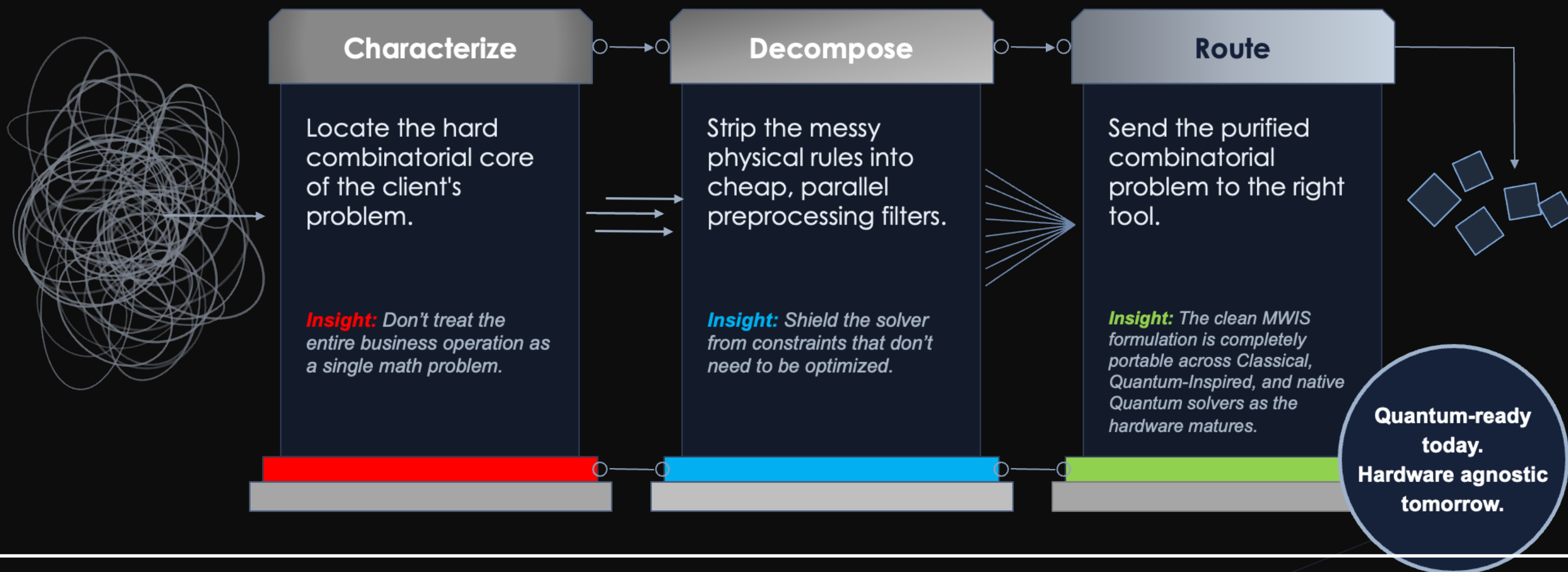
Can we...?

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.



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