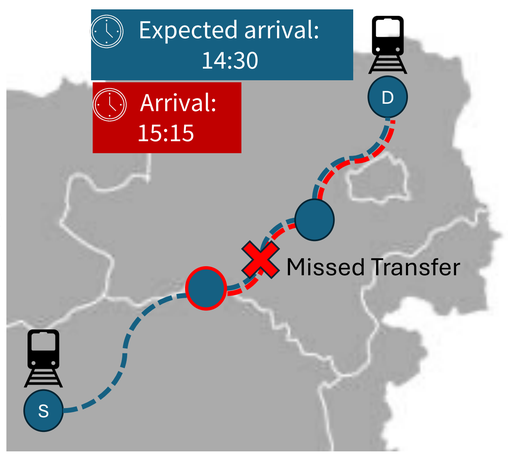
Never stranded – Stay on track with backup travel planning

Denis Vorontsov, Diana Lutska & Paulina Heine

The Problem

Missing Train Connections Disrupts Travel Planning

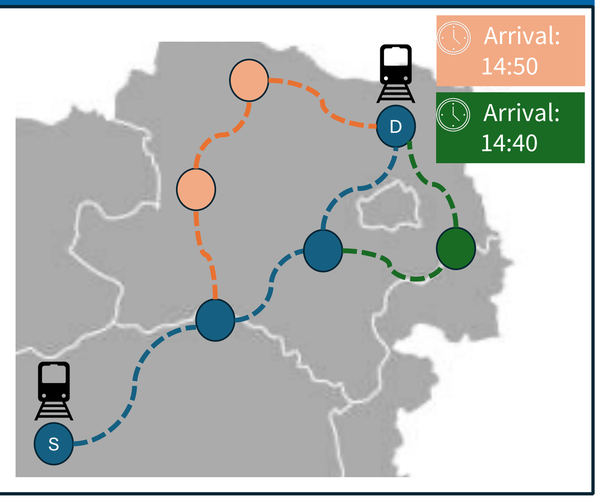
Assume you have to go from S to D, because there is a concert at D at 15:00. Here you see the fastest connection in blue (**the primary route**), but you have to change trains on the blue nodes.
Missing a connection can prevent you from reaching your destination before 15:00, as red path illustrates.



The Solution

To prevent missed connections from disrupting travel plans, we propose **backup routes at every transfer point.**
We provide alternative ways to arrive on time if one transfer is missed and to improve the **reliability of the itinerary**.

By implementing backup planning, the **travel efficiency is improved**.
The whole construct of primary route and backups is the **itinerary**



What is Reliability?

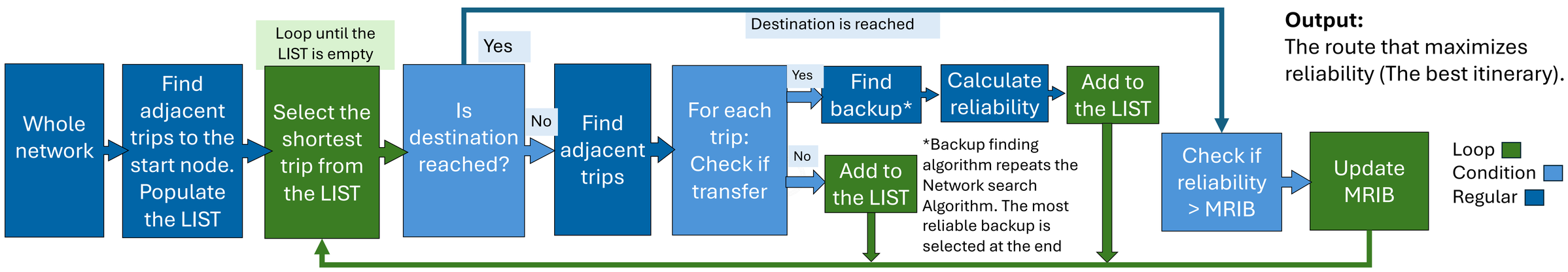
Reliability of the route is the probability of reaching destination on time. To calculate reliability of the route, we deal with **four types of reliability:**

Transfer reliability → 1 if there is no transfer; {0, 0.95} if there is a transfer, depending on the transfer time;
Primary Route reliability → $\prod t$, the product of all transfer reliabilities on the primary route;

Backup Route Reliability → $\prod t$ on the backup route * probability to miss the connection on the transfer point where the backup starts * reliability of primary itinerary before the transfer point;
Itinerary Reliability → Primary route reliability + reliability of all backups;

Most reliable itinerary with backups (MRIB) - Redmond et al., 2022

Goal: Find the most reliable travel route with backup options to ensure on-time arrival despite possible delays or missed connections.

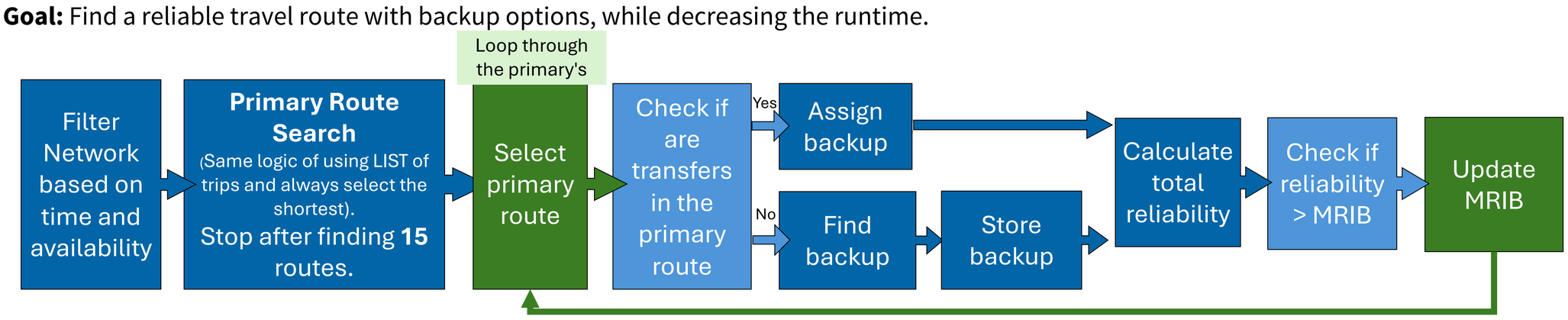


Output:
The route that maximizes reliability (The best itinerary).

This algorithm has many loops and checks every possible route, which is computationally expensive. For a complex network system, the algorithm has to check too many possible routes. The Algorithm is so complex, that it **did not finish on our computers most of the time**. It might be useful to have a faster alternative, the VRIB.

Very reliable itinerary with backups (VRIB)

Goal: Find a reliable travel route with backup options, while decreasing the runtime.



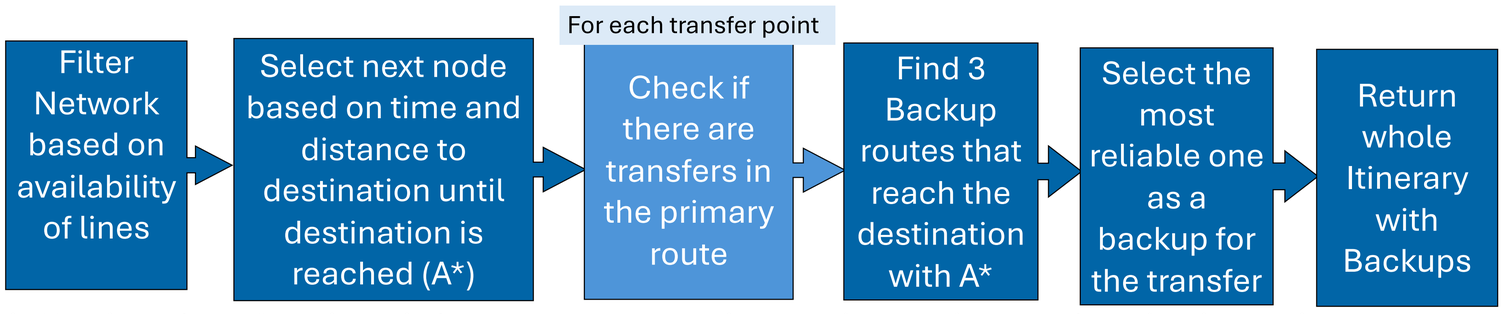
Network search optimization:
Between any 2 nodes only the shortest and most reliable trips are evaluated.

Output:
The route balances optimality and runtime.

This Version still follows the general logic of the MRIB, but the primary and backup search loops are separated, in order to optimize it. Furthermore, the backups for the same transfers are stored and reused. Nevertheless, the runtime is still high, it takes around 10 minutes to finish.

A reliable itinerary with backups via A* (ARIB)

Goal: Search for one fast route to the destination. Then searches for 3 backup routes for each transfer point, selecting the one out of those with the highest reliability.



Output:
A fast route with good backups for each transfer point.

Network search optimization:
Instead of Dijkstra like in the MRIB and VRIB, we used A*. Thus, not only travel time, but also the distance change to the destination is taken into consideration

This Version of the Algorithm is focused on the runtime; while running very fast, it still provides reasonably good solutions. However, it not always finds the best solution. In a realistic setting, a solution that comes fast and is not the optimum might be more useful than a solution that takes hours to compute.

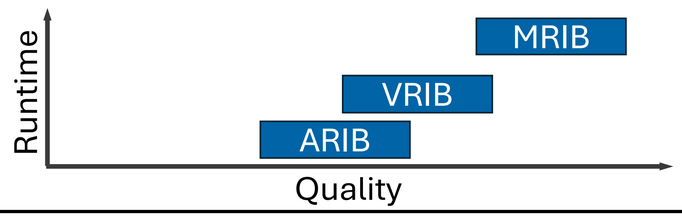
The Data

General Transit Feed Specification (GTFS) data from **ÖBB 2024**.

Challenges:
Inconsistent station names due to spelling variations.
Network density impact: The denser the network at departure or arrival points, the longer the algorithm runtime.

The Results

	MRIB	VRIB	ARIB
Runtime	inf	fast	very fast
Reliability	max	very high	high
Duration of trip	/	very fast	fast



There is a **trade-off** between the **runtime** of the algorithm and the **quality** of the solution

This is a possible UI, showing the primary route and the backup routes where they are available.