Air-Rail timetable synchronization for a seamless passenger journey

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Context and objectives

- The European Commission sets for 2050 the objective that 90% of travelers are able to travel **door-to-door** in Europe within 4 hours
- Integrate air transportation within ground transportation modes at the **strategic** level
- Provide passengers with a seamless trip

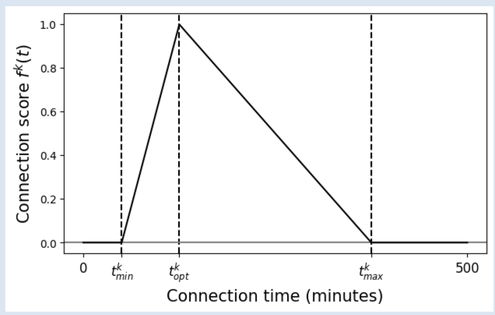
Scientific challenges

- Gather **data** from different sources (air, rail, public transport)
- Consider all stakeholders constraints
- Shift from a transportation-oriented metric to a **passenger-oriented metric**
- **Computation** cost of the integrated air-rail timetable

How to assess an integrated timetable quality?

- Passengers are subject to trains and flights schedules that are designed independently

- Definition of a passenger-oriented metric to assess the quality of a connection time between two modes



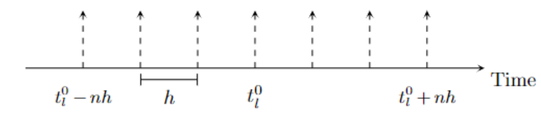
- Higher score for an optimal connection time
- Long and short connection times are penalized to avoid waiting time and stressful situation for passengers
- Asymmetrical shape : we assume that longer connection times are preferable than short ones to avoid missed connections in case of delay

The Air-Rail timetable optimization problem

Baseline

- Each flight or train has an initial departure or arrival time from/to one airport/train station
- These schedules are independently build

Only small changes will be applied to the initial schedules.



Lever of action

- For each flight/train, we created new possible departure/arrival times around the initial ones
- The number of backward and forward possibilities is limited

Constraints

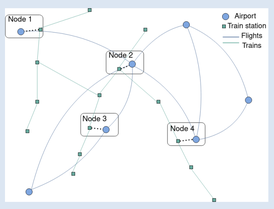
- Airport capacity
- Train stop duration at station
- Aircraft turnaround times

Resolution method

MIP solver	Metaheuristic (Simulated Annealing)
+ Proof of optimality + Easy to implement	+ Computational time - No guarantee of optimality

Future works

Extend the model to the European transportation network



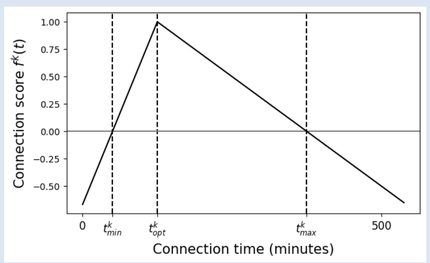
Include robustness in the optimization tool:

- Trains and flights may not arrive/depart at their schedule times due to disruptive event
- The new schedule time will consider potential delay
- The objective changes : minimization of the worst delay that passengers could experience with the integrated schedule
- Use of stochastic optimization

Use real passenger data

- Passenger mobile phone data can be processed to estimate door-to-door travel times
- These data bring information on the connection time between modes and passengers behavior (conservative or not)

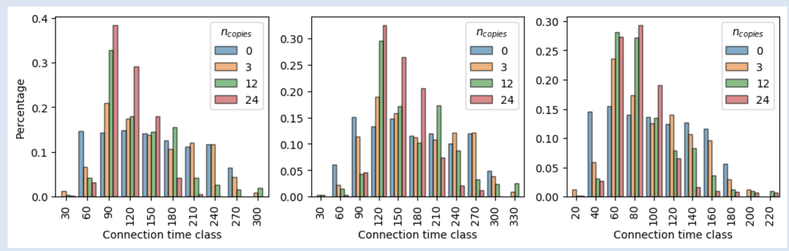
Improve the model to reduce MIP solver computation time



Paris-CDG case study

December 4th, 2019:

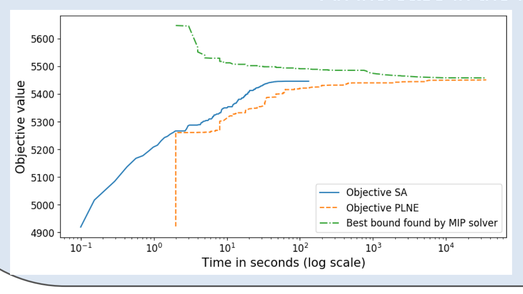
- 1163 flights
- 66 trains
- Simulation of a passenger demand with more than 7000 connections to consider



Connection time distribution evolution:

A change limited to 15 minutes from the initial schedule leads to:

- A decrease in the proportion of short connection times in the integrated schedule
- An increase in the number of suitable connections for passengers



Numerical results:

- The metaheuristic implemented found a solution in 130s at 1% of the better solution found with exact method
- Same quality solution found with exact solver in 20 minutes

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