The role of timetable, rolling stock rescheduling and information strategies to passengers in public transport disruptions

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The Role of Timetable, Rolling Stock Rescheduling and Information Strategies to Passengers in Public Transport Disruptions

1 Introduction

Public transport disruptions

- Malfunctions last more than two hours
- Partial technical components are unavailable

Multi-modal network

- Rail
- Bus/ Tram
- Car/ Bike/ Walk

Interaction on passengers

- Timetable
- Rolling stock
- Information

2 Information Strategies and Passengers' Adaptation

No information

Advance information

Timely information

3 Agent-based Simulation Approach

The present work uses the MATSim platform for agent-based simulation, with different disposition timetables generated by an optimization model of timetable and rolling stock rescheduling.

- The default MATSim works by reaching an equilibrium solution. (Benchmark)
- No extra replanning, agents wait and postpone initial plans. (No info)
- Alternative routes/ modes/ time/ activities to new equilibrium. (Advance Info)
- Rerouting after disruption starts using within-day replanning. (Timely Info)

MATSim execution of different information strategies and disposition timetables

4 Timetable and Rolling Stock Rescheduling

A mixed integer programming (MIP) model is applied with train order binary variables, which can be solved by commercial solver. The objective of the optimization model is to minimize the total delay of passengers. The timetable rescheduling includes the strategies retiming, reordering, rerouting, cancellation of train services. In addition, the rolling stock circulation is checked to ensure the feasibility of the disposition timetable. Examples of different schedules are :

- No rerouting vs. Rerouting: rerouting the disrupted train services from "Route 1" to "Route 2".
- Fully cancelled vs. partially cancelled: depending on whether the trains serving the stations beyond station A or station B are cancelled or not.
- Rolling stock circulation (partially cancelled): green line shows the feasible rolling stock circulation; otherwise, the services are fully cancelled.

Explanations of different schedules

5 Test Case

Zürich scenario

The public transport integration is implemented in the Zürich network, i.e. any multimodal trip between origin and destination is available to public transport users without extra charges.

The assumed rail disruption: the green and red dashed lines unavailable between 16 and 19 o'clock.

- All long-distance train services can be rerouted on the available undisrupted route;
- Local S-bahn services are kept if a feasible rolling stock circulation can be found.

6 Results

Schedules

Due to “rerouting”:

59.5% of trains can still run on the alternative route (DML), resulting train Service originally on DML suffer average delay 3.3 min.

“Retime” keeps the trains:

- 4.4% via Zürich Hardbrücke (8.7 min)
- 5.4% via Zürich Wipkingen (3.7min)
- The total average delay is 3.6 minutes.

Due to the feasibility of **rolling stock** circulation, some trains are fully cancelled:

- 1.5% via Zürich Hardbrücke
- 2.7% via Zürich Wipkingen

Passenger delays and scores

We classify the agents into three groups:

- “**involved agents**”: via either Zürich Wipkingen or Zürich Hardbrücke between 16 and 19 o'clock.
 - Advance information**: **rolling stock** can be **as important**, if not **more important** than **rerouting**.
 - Timely information**: the benefit of **partial cancellation** is **higher** than that of **rerouting**.
 - No information**: agents reports **limited improvement** from **rerouting** and **partial cancellation**.
- “**DML agents**”: via the direct tunnel route (DML) during the defined disruption time.
 - 2.7 min **more delay** due to the “**rerouting**”: agents’ delay is just related to train delay, and **information** plays a **minor** role.
- “**the others**”: agents using both either because of multiple trips, or because they need to transfer.
 - The **largest** benefits if operating companies can **keep** the services **beyond** the involved stations.
 - The benefit of **information** and **rerouting** services is **rather limited**.

Agents’ average delay (minutes) and average score (%) due to disposition timetables and information strategies

rescheduling strategies		Agents’ average delay (minutes)					Agents’ average score (%)				
		no rerouting		rerouting		Average, all schedules	no rerouting		rerouting		Average, all schedules
rolling stock		fully	partially	fully	partially		fully	partially	fully	partially	
involved agents (125)	no info	137.2	137.2	128.8	128.8	133	-943.6	-943.6	-891.8	-891.8	-917.7
	advance info	16.1	5.4	8.9	2.1	8.1	-76.8	-32.9	-46.8	-14.2	-42.7
	timely info	59.4	28.5	49.8	20	39.4	-337.1	-107.8	-297.5	-72.2	-203.7
DML agents (56)	no info	0	0	2.7	2.7	1.4	0	0	-10.7	-10.7	-5.4
	advance info	0	0	1.2	1.2	0.6	0	0	-5.8	-5.8	-2.9
	timely info	0	0	2.7	2.7	1.4	0	0	-10.7	-13.7	-6.1
others (30)	no info	130.3	19	121	12.5	70.7	-541.2	-104.5	-528.9	-62.5	-309.3
	advance info	11.2	7.1	9.2	6.4	8.5	-34.3	-18.6	-24	-12.2	-22.3
	timely info	114.8	15	108.2	10.5	62.1	-528.5	-56	-524.2	-40.1	-287.2
Average, all agents (211)	no info	99.8	84	94.2	78.8	89.2	-636	-573.9	-606.4	-540	-589.1
	advance info	11.1	4.2	6.9	2.5	6.2	-50.4	-22.1	-32.7	-11.7	-29.2
	timely info	51.5	19	45.6	14.1	32.5	-274.8	-71.8	-253.6	-52.1	-163.1

7 Conclusions

We study passengers’ satisfaction in public transport disruption in a multi-modal network, under different disposition timetables and information strategies, combining an optimization model and agent-based simulation.

- From the results of a test case in Zürich, there is capacity for many trains to be kept running despite the disruption on an **alternative railway route**; this allows running **more trains** against a **minor delay** (3.6 min on average, including rerouted and original train services). The challenges related to **rolling stock** still require a **minor** amount of train services to be **cancelled**.
- Our results show that the **information** strategy is a **major** driver of delays: the **earlier** the agents can receive the disposition timetable, the **smaller** the **delay** they will suffer in disruption.
- Being able to **partially cancel** trains based on a feasible rolling stock circulation is **much better** for passengers than **full cancellation**, especially for passengers crossing the disrupted area **multiple times**. This might require multiple adjustment in the rescheduling process of the company, for **additional operation complexity**.
- Train **rerouting** is able to **tradeoff** between a **large delay for involved agents** and a **slight delay** (2.7 min on average) for agents on the **alternative route**, assuming agents have enough information to benefit from this change of plans. At system level, the impact of a disruption can be reduced substantially in this way, with a **utility** impact of the disruption **reduced to a fifth only**, of the original impact, assuming the realistic **timely information** strategy.

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