Trade-offs among passengers, train operators and infrastructure managers in railway disruptions

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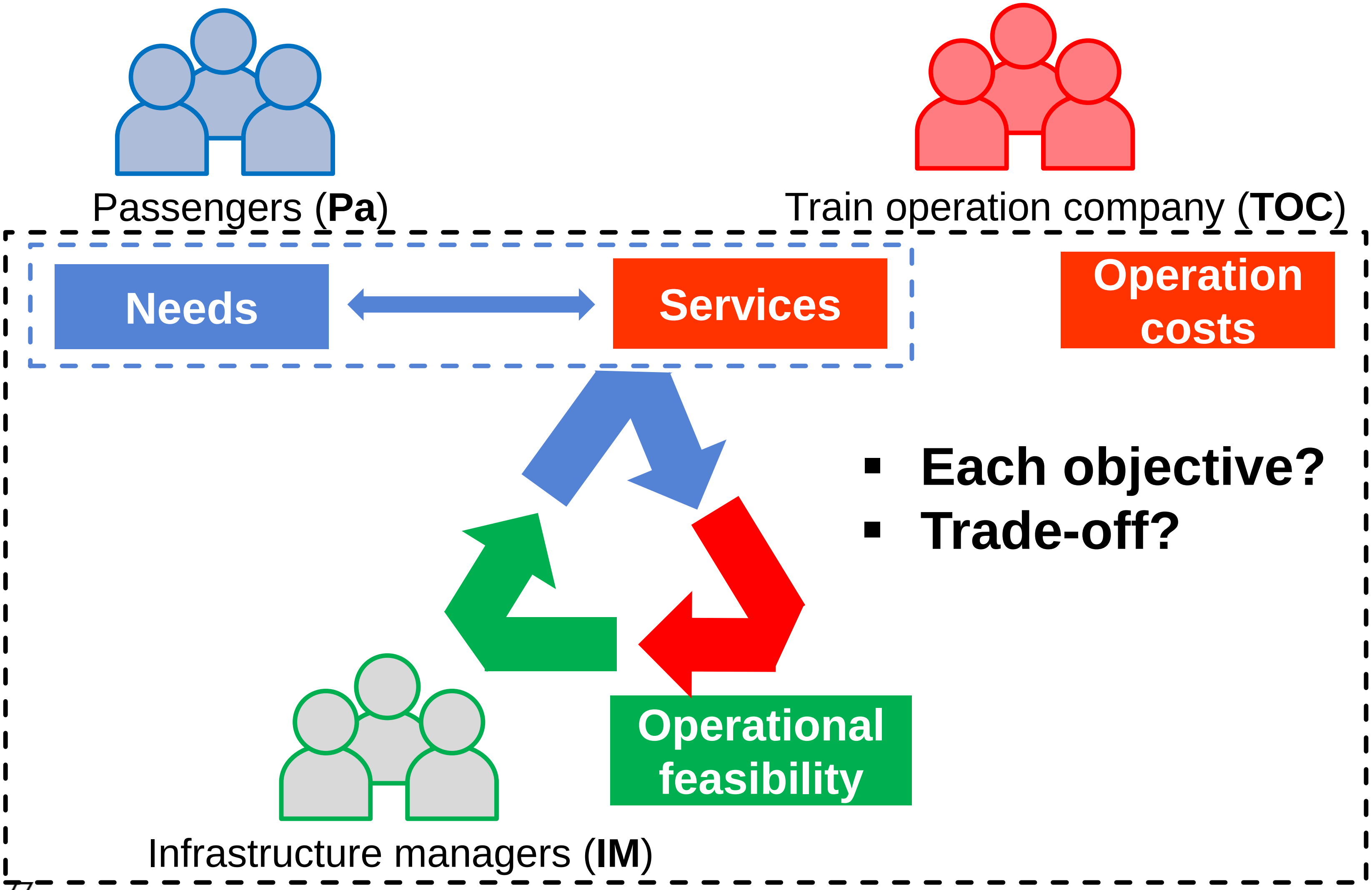
Railway disruption management problem



- Each objective?
- Trade-off?

Passengers' objectives

Influencing factors	Indicators from network viewpoint	Indicators from passenger viewpoint
1.Replacing services	• Number of denied passengers in railway	• Number of choices in railway • Number of choices by other mode • Extra costs of replacing services
2.Travel time	• Train delay	• In-vehicle time • Waiting time • Transfer time
3. Convenience	• Missing connection • Changing platform	• Numbers of transfers • Transfer distance at stations
4. Comfort	• Train congestion • Station congestion	• Seats on board • Baggage, air conditioner

Train operators' objectives

Costs	Indicators
1. Trainsets	• Minimising total number of trainsets (and staff) involved in disruption management
2. Unplanned service	• Minimising operation costs connected with unplanned allocation of rolling stock (and staff) • Minimising unplanned stops
3. Empty movements	• Operating approximately same train numbers in each direction (balancing the number of trains in both directions)

Infrastructure managers' objectives

- Limiting propagation of (network-wide) train delay spread
- Recovering from disruptive events as quickly as possible
- Avoiding deadlock in the network
- Avoiding overload of lines

Trade-offs of three stakeholders

Algorithm 1: Mixed Integer Programming

$$\min d(p) + f(t) + s(r)$$

Subject to $t \in \tau$

$$p \in \rho_\tau$$

$$r \in \gamma_\tau$$

$$\sum_k u_r^k = 1$$

A train uses only one track at a station

$$a_r^{Next(b,s)} - d_r^s \geq I_{b,e}^s - M\left(1 - l_{r,e}\right)$$

Minimum running time

$$\sum_{r \in R_b} z_{t,r}^{o,d} = 1 \quad \forall b \in B \forall (o,d) \in S_{b<>}^2, \forall t \in T$$

A passenger chooses only one train

$$z_{t,r}^{o,d} \leq \frac{d_r^o}{t} \quad \forall b \in B \forall (o,d) \in S_{b<>}^2, \forall t \in T \forall r \in R_b$$

A passenger cannot catch a train which departs before

$$z_{t,r}^{o,d} \leq 1 - l_{r,e} \quad \forall b \in B \forall (o,d) \in S_{b<>}^2, \forall t \in T \forall r \in R_b \forall e \in E \setminus E^{o,d}$$

A passenger chooses a route to his/her destination

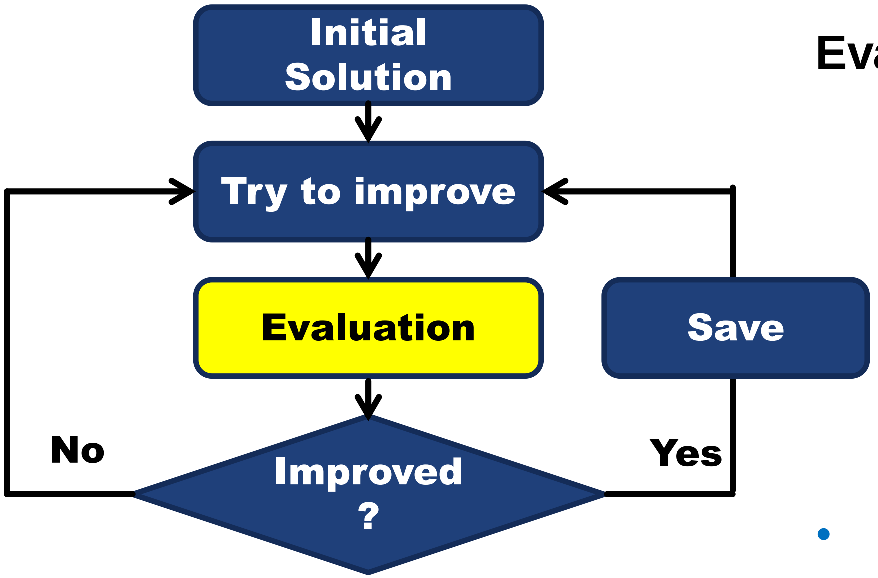
…

…

	MIP
Non-linearity	×
Processing time	× ×
Optimality	○
Algorithm Design	△

Trade-offs of three stakeholders

Algorithm 2: Metaheuristics



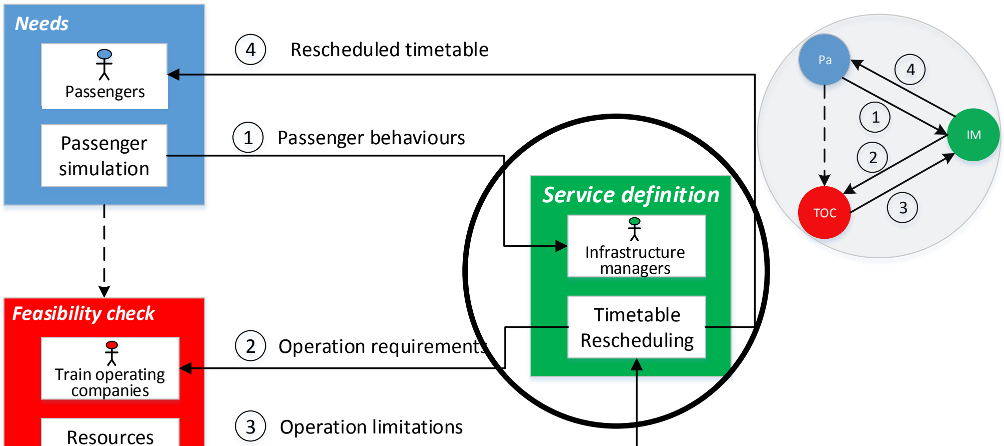
	Metaheuristics
Non-linearity	○
Processing time	△
Optimality	×
Algorithm Design	×

Evaluation from passengers' viewpoint

- use Simulation simulate passengers' flow
- sum up each passenger's travelling time, congestion, …

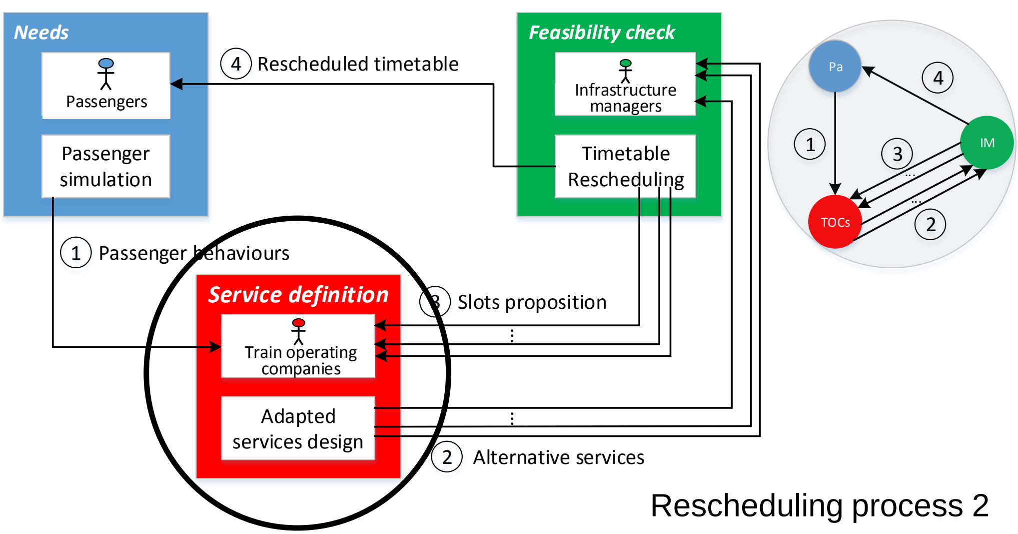
- Passenger behaviours in case of railway disruptions
  - Multi-Agent Transport Simulation
  - Plan selection based on scoring objectives

Trade-offs of three stakeholders



Rescheduling process 1

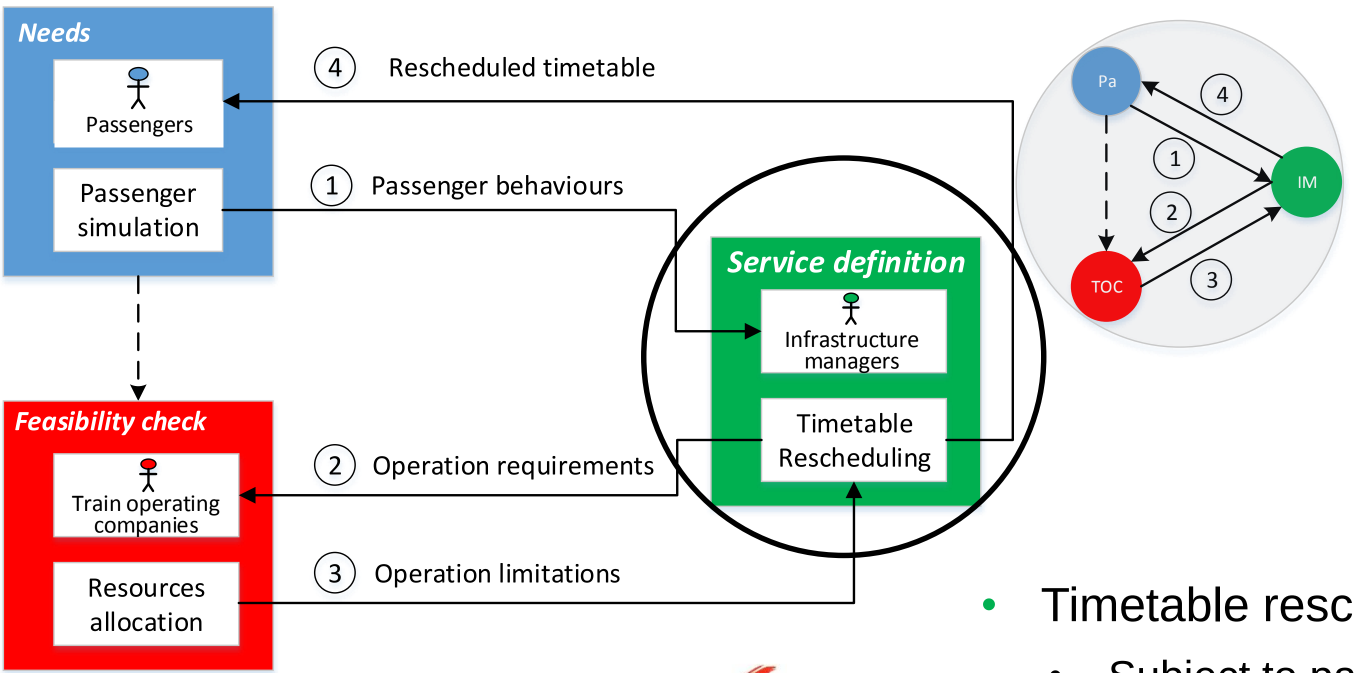
- Timetable rescheduling (on-line)
- Weak link between passengers and train operators
- Short computation time



Rescheduling process 2

- Line planning and timetabling (off-line)
- Strong link between passengers and train operators
- Long computation time

Trade-offs of three stakeholders



Rescheduling process 1 ✓

- Timetable rescheduling
  - Subject to passenger information and resources availability
  - Multiple rescheduling strategies
- Rolling stock rescheduling
  - Subject to rescheduled timetable

Conclusions

- **Main work**
  - The respective objectives of three stakeholders – passengers, train operators and infrastructure managers.
  - Link three stakeholders in the dispatching process of railway disruptions

- **Future research**
  - Passenger behaviours in case of railway disruptions
  - Timetable and rolling stock rescheduling in railway disruptions
  - Holistic model considering the interactions of stakeholders

Thanks for your attention!

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