Pattern-based train rescheduling and its evaluation method in temporal speed restricted situations

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Background

- In order to introduce a decision-support system, it is important for users to understand the output from the system.
- Using “patterns” prepared by train dispatchers is one of the promised ways to construct a practical train rescheduling support system.
- “Patterns” can be specified with three predetermined factors (Nakamura et al., RailRome2011).
- It will not be perfect, but train dispatchers can prepare explainable “patterns”.
- In the basic idea, “patterns” are unique, so it would not be necessary to evaluate them.
However, especially under the speed restricted situations, it is hard for train dispatchers to find unique “patterns”

- Train dispatchers would request how the patterns can work

In order to find the most suitable patterns, we introduce some measures and a simulation technique to evaluate them under speed restricted situations
Outline

- Phases of train rescheduling arrangements at a control centre
- Concept of train rescheduling with patterns
- Temporal speed restricted situation
- Train rescheduling under the situation
- A simulation technique
- Evaluation measures
- Case study
- Conclusion
Phases of train rescheduling arrangements

Train dispatcher (Decision maker)
- Receive and assemble information on the accident
- Estimate what time the train operation can resume
- Decide train cancellations and turn-backs of the trains at the turn-back stations

Train dispatcher (Follower)
- Stop trains to keep safety and to make it possible for them to turn-back
- Change departure order and tracks at stations
- Input orders to a train traffic control system
- Inform depot and crew offices of decisions

Command sheets

Train rescheduling at a control room
Concept of train rescheduling with patterns

We can prepare patterns for train rescheduling by the following elements

- Train group
- Train cancellation section
- Turn-back pattern
Concept of train rescheduling with patterns

Station A
Train 1
Train 3
Train 5
Train 7
Train 9
Train 11
Train 13
Train 15
Train 17

Station B

Station C

Station D
Train 2
Train 4
Train 6
Train 8
Train 10
Train 12
Train 14
Train 16

Interrupted zone

Time
Concept of train rescheduling with patterns
Concept of train rescheduling with patterns

“Turn-back” patterns

Interrupted zone

Time
Temporal speed restricted situation

- Temporal speed restricted situation
  - Heavy rain
  - Strong wind
  - Other reasons to drive carefully to watch situation along the line

- To keep safety, trains have to run at the lower speed

- Low-speed driving can cause delay

“Slow down”
Trains operated without any disruptions

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Delay caused by an accident
Delay caused by speed restriction
Under the speed restricted situation

- Trains can run but the speed restriction can cause delay and traffic disruption.
- On the other hand, cancelling all trains will cause the lack of transport capacity.
- Some trains are to be cancelled to keep the capacity to some extent.
- It would be desirable to predetermine how trains are to be cancelled.
Delay caused by speed restriction
Cancelling all trains at the restricted section
Cancelling every other train
Cancellation pattern examples
A simulation technique

- It is necessary to introduce a quick simulation technique to select patterns in practical use if train dispatchers need to evaluate them just after trains are to be slow down.

- For railway lines where daily timetables are always the same, evaluations can be done in advance. So, detailed simulation techniques are recommended.
A simulation technique

Station A
Train 1
Node 1
Node 7
Train 3
Node 3
Node 8
Node 9

Station B
Train 1
Node 2
Node 3
Train 3
(Node 1)
Train 1, Station A, Departure
(Node 7)
Train 3, Station A, Departure

Station C
Train 1
Node 4
Node 5
Train 3
(Node 2)
Train 1, Station B, Arrival
(Node 8)
Train 3, Station B, Arrival

Station D
Train 1
Node 6
Node 12
Train 3
(Node 3)
Train 1, Station B, Departure
(Node 9)
Train 3, Station B, Departure

(Node 5)
Train 1, Station C, Departure
(Node 10)
Train 3, Station C, Departure

(Node 4)
Train 1, Station C, Arrival
(Node 11)
Train 3, Station C, Arrival

(Node 6)
Train 1, Station D, Arrival
(Node 12)
Train 3, Station D, Arrival
A simulation technique with extra time

Station A

Train 1

Train 3

t_plus

Station B

Speed-restricted section

Station C

Station D

Time

(Node 1)
Train 1, Station A, Departure

(Node 2)
Train 1, Station B, Arrival

(Node 3)
Train 1, Station B, Departure

(Node 4)
Train 1, Station C, Arrival

(Node 5)
Train 1, Station C, Departure

(Node 6)
Train 1, Station D, Arrival

(Node 7)
Train 3, Station A, Departure

(Node 8)
Train 3, Station B, Arrival

(Node 9)
Train 3, Station B, Departure

(Node 10)
Train 3, Station C, Departure

(Node 11)
Train 3, Station C, Arrival

(Node 12)
Train 3, Station D, Arrival
Evaluation measures

- Train traffic capacity
  - Ratio of the number of trains (Simulation / Original)

- Variance of train time intervals
  - Ratio of the variance of intervals (Simulation / Original)

- Same-time train running
  - The number of trains that trace the train times on the original timetable

- Propagation of delays
Case study

- The target line connects an urban city area and a suburban area
- Based on a real train rescheduling plan, we prepare normal plans and extreme plans
Plan 1: Small modification

Plan 2: Cancelling all trains
Plan 3: Cancelling every other train

Plan 4: Cancelling every other trains
Ratio of variance values

$r_v = \frac{\text{Variance value of the \textbf{simulated} departure time intervals at the station}}{\text{Variance value of the \textbf{original} departure time intervals at the station}}$

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<td>1.7</td>
<td>3.0</td>
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<td>1.0</td>
<td>4.0</td>
<td>4.4</td>
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<td>Station E</td>
<td>3.0</td>
<td>1.0</td>
<td>1.3</td>
<td>1.2</td>
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Conclusion and future work

- Basic concept of train rescheduling arrangements under speed restricted situations
- Some measures to evaluate train-rescheduling results
- Simulation case studies show the such measures can show differences of the quality of train rescheduling plans

- We have to add other measures considering special role of trains
  - The first train have not to be cancelled
  - Trains that enters other lines have to be cancelled