

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

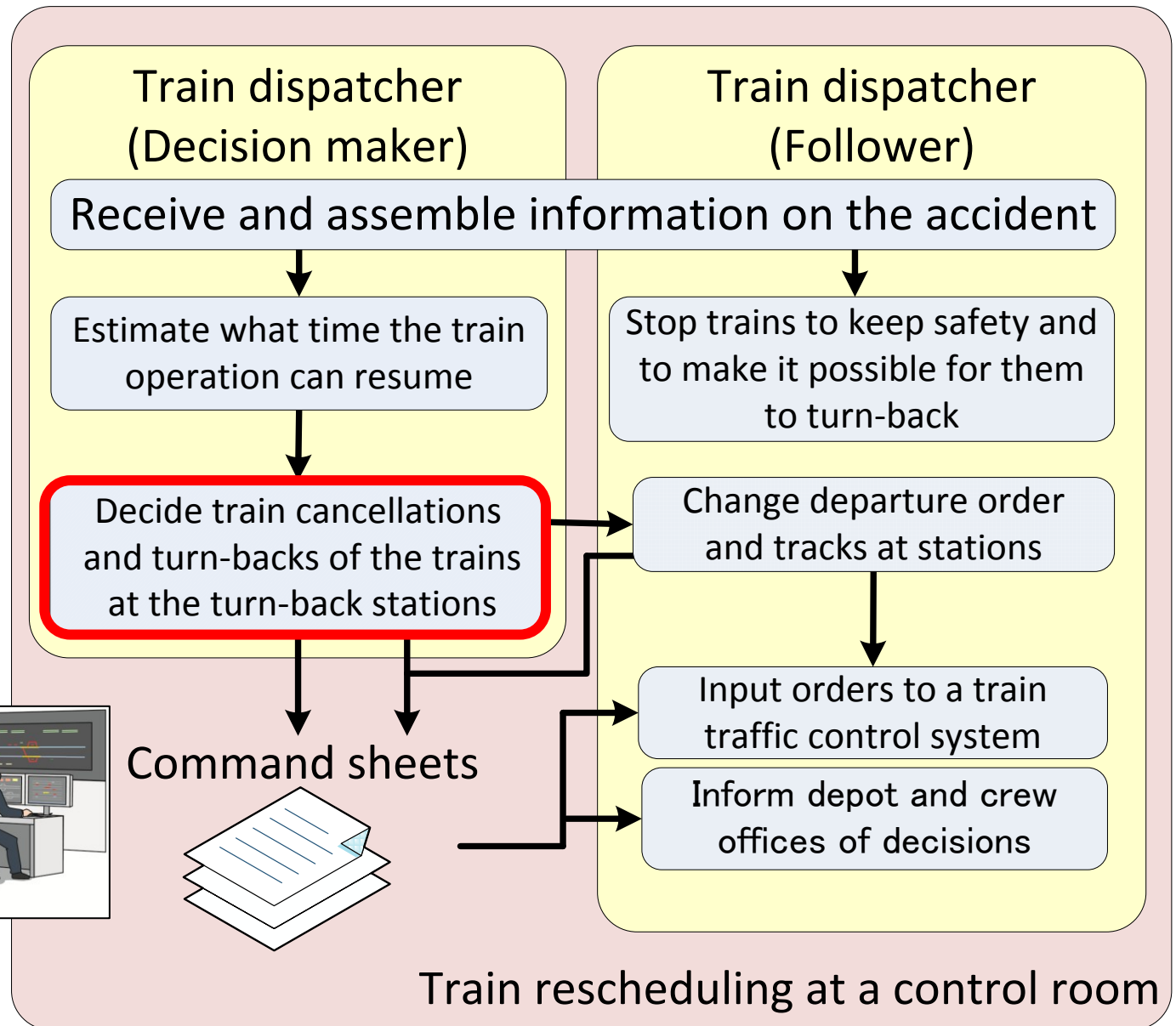
Background

- 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

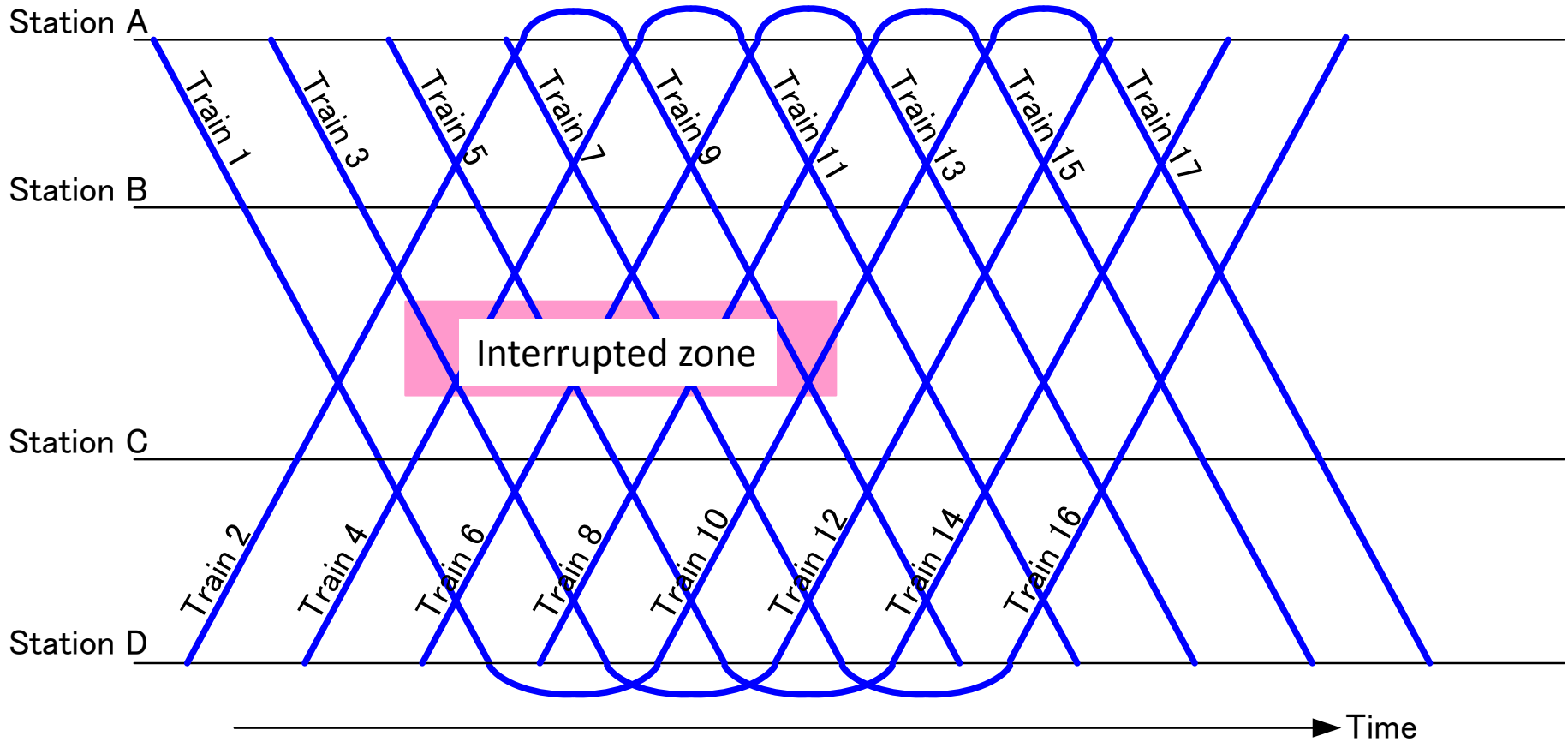
Phases of train rescheduling arrangements



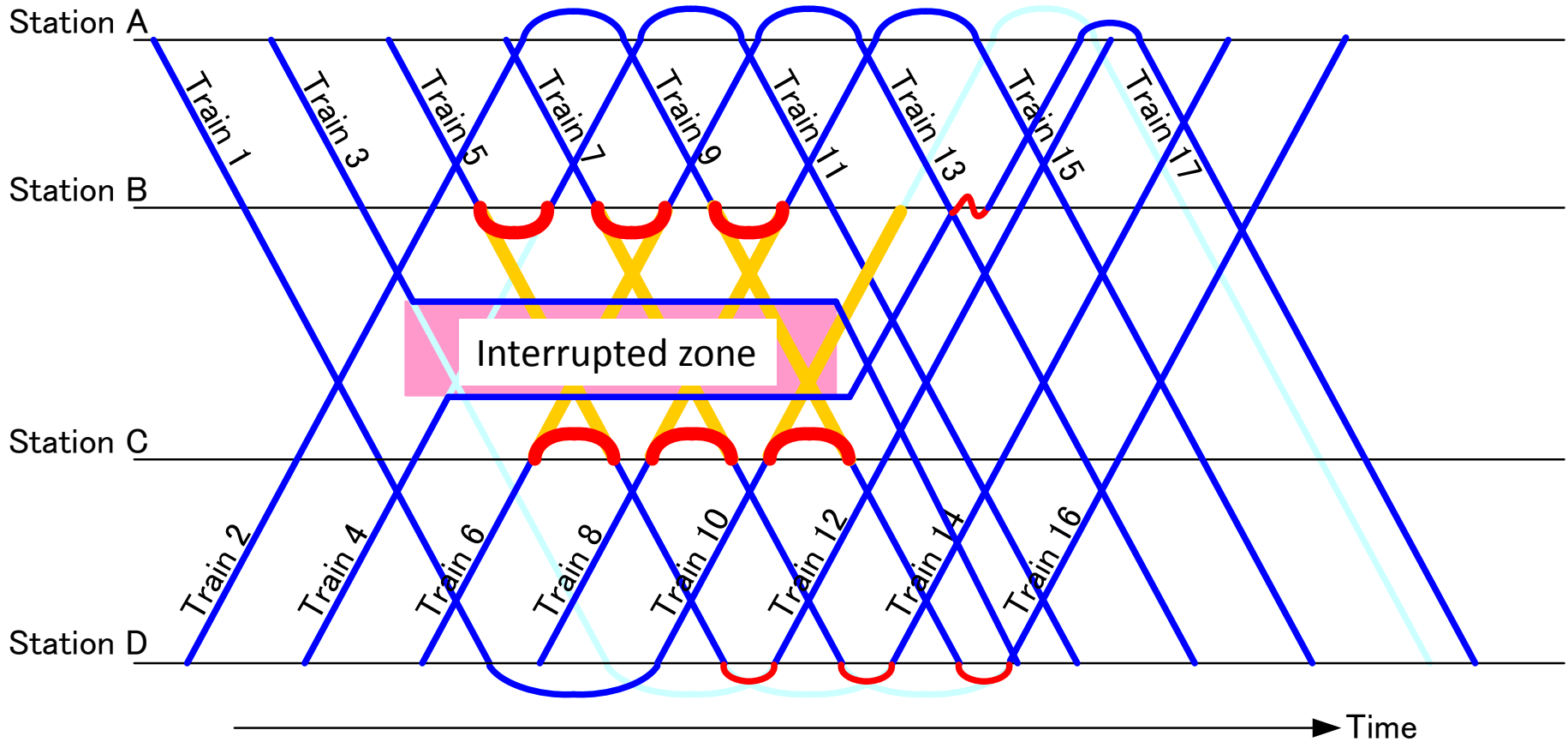
Concept of train rescheduling with patterns

- We can prepare patterns for train rescheduling by the following elements
 - Train group
 - Train cancellation section
 - Turn-back pattern

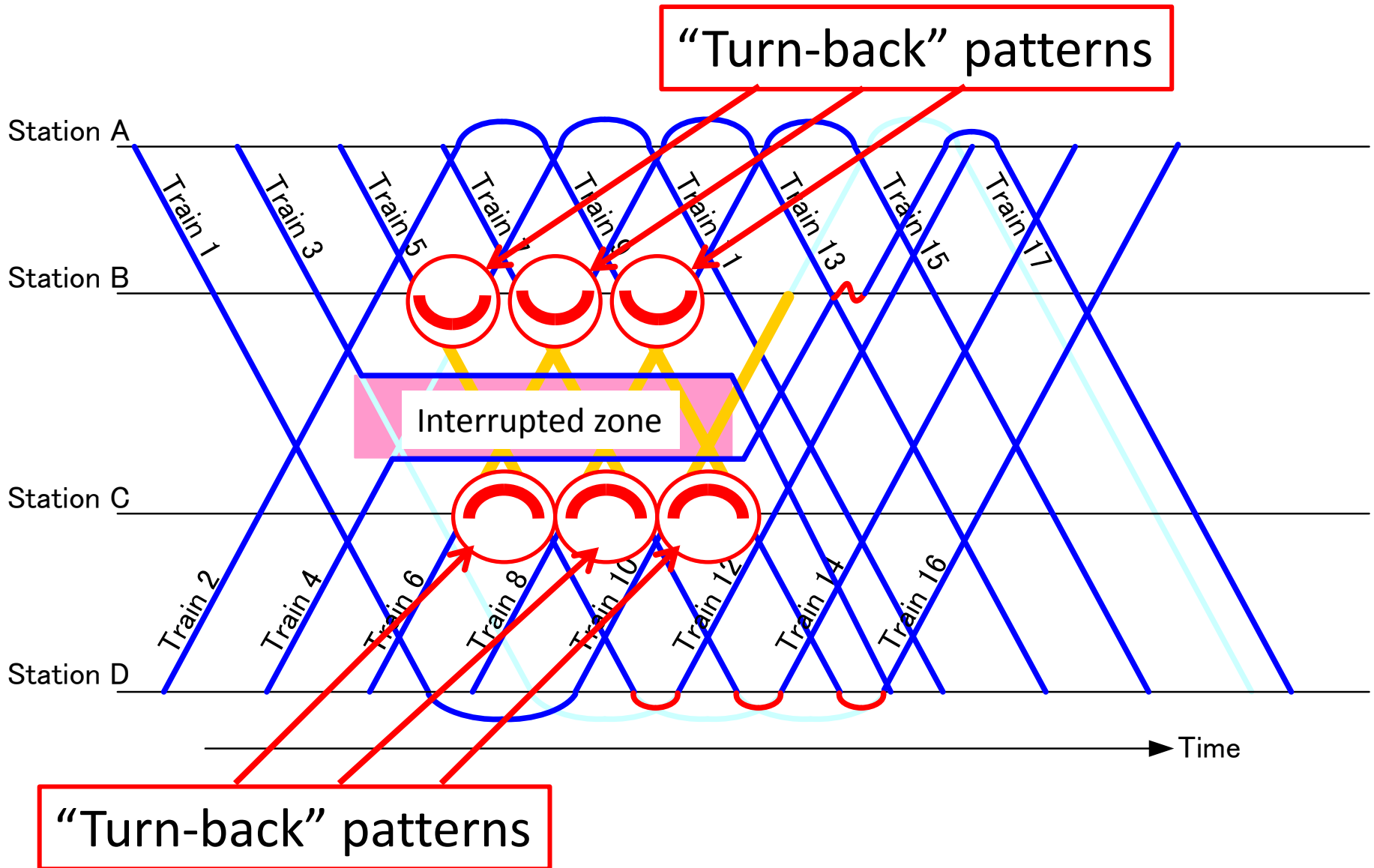
Concept of train rescheduling with patterns



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Concept of train rescheduling with patterns

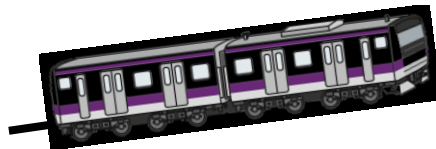


Temporal speed restricted situation

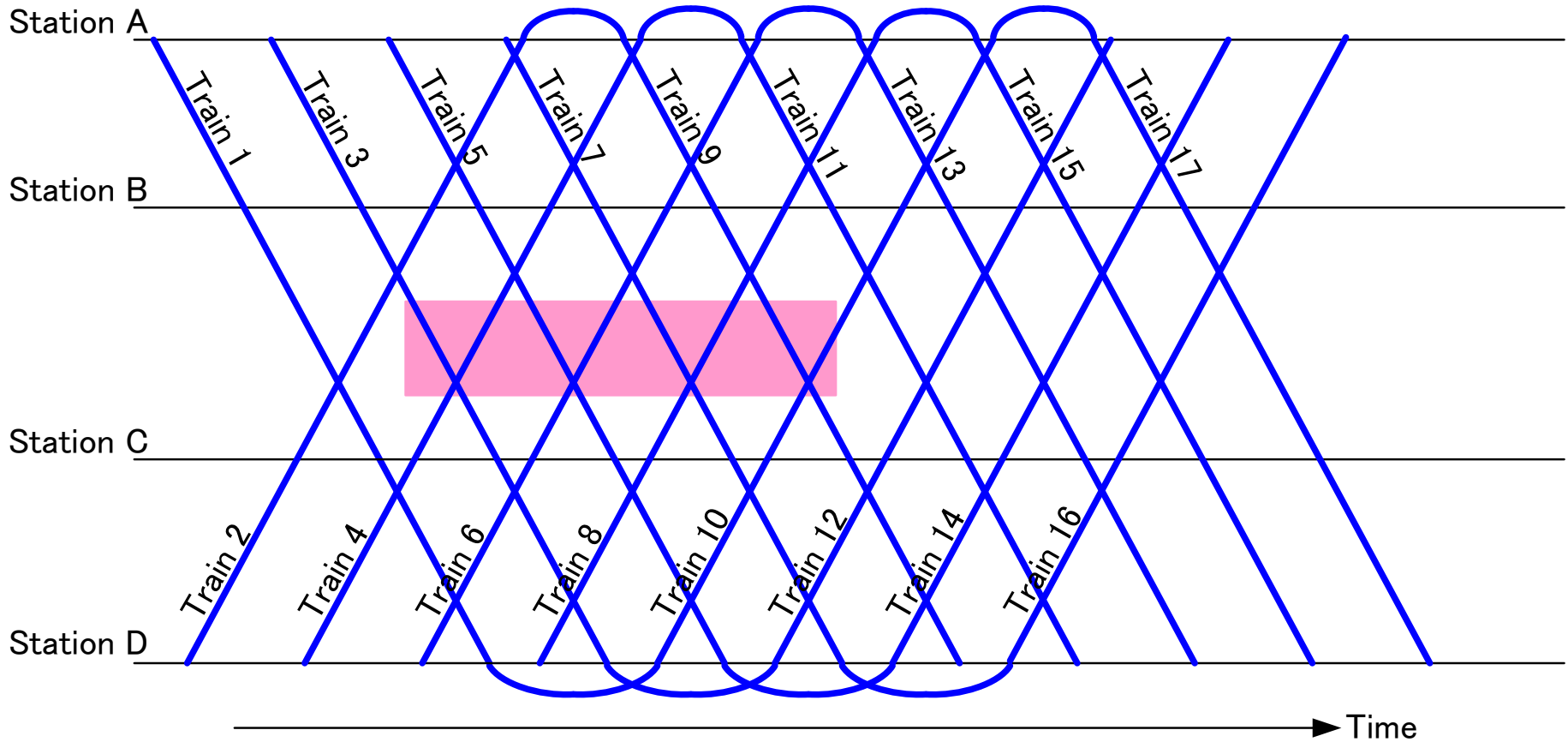
- Temporal speed restricted situation
 - Heavy rain
 - Strong wind
 - Other reasons to drive carefully to watch situation along the line
- To keep safety, trains have to run at the lower speed
- Low-speed driving can cause delay



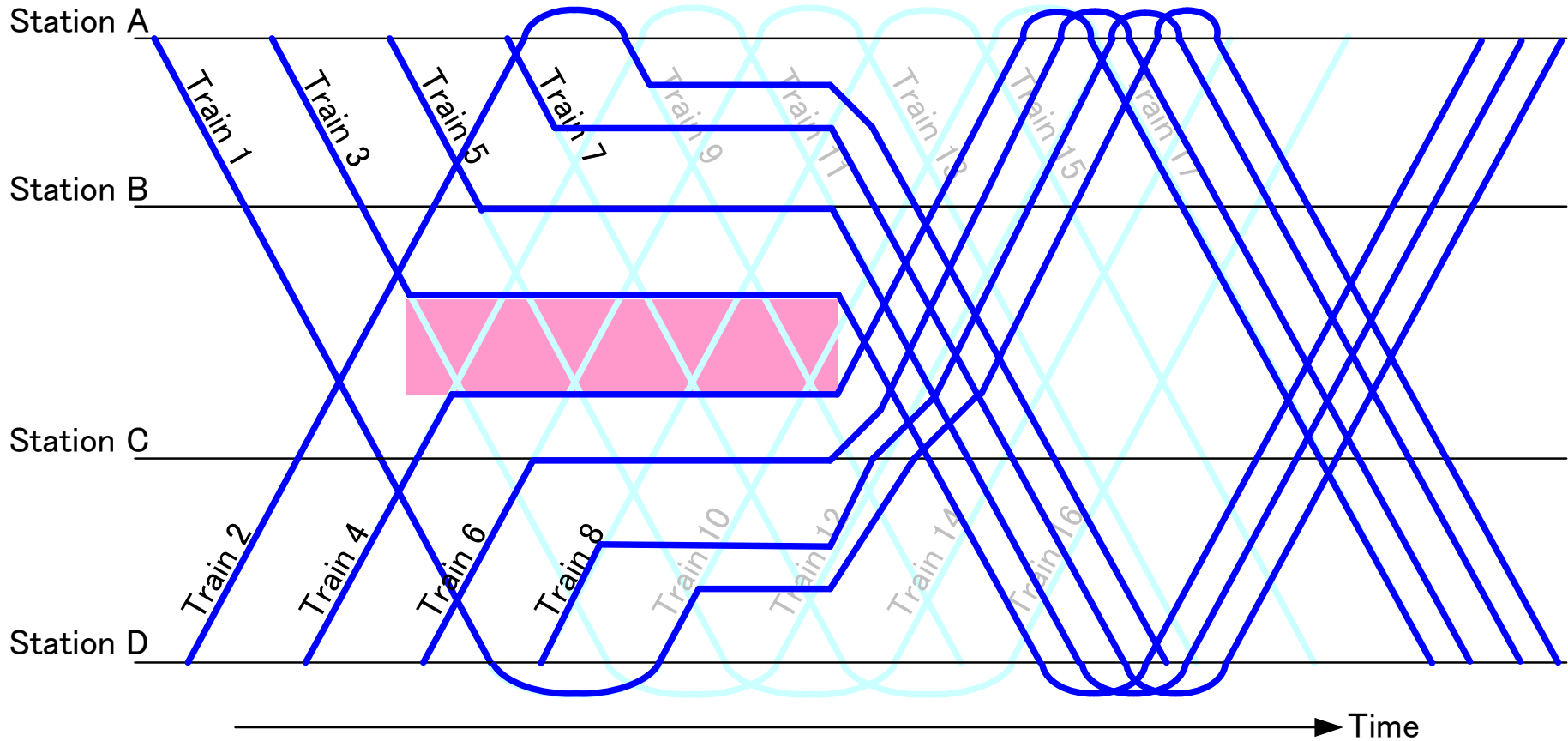
“Slow down”



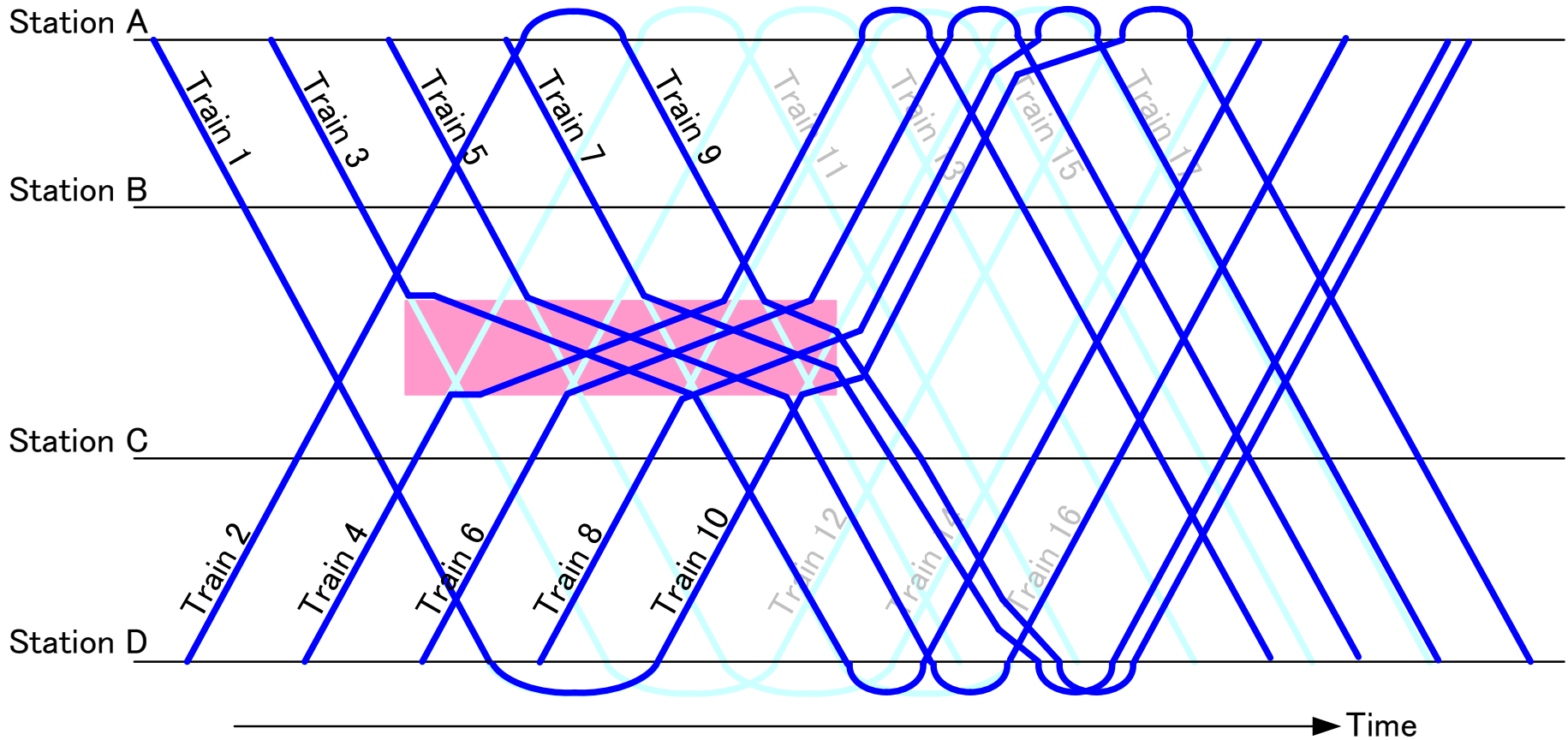
Trains operated without any disruptions



Delay caused by an accident



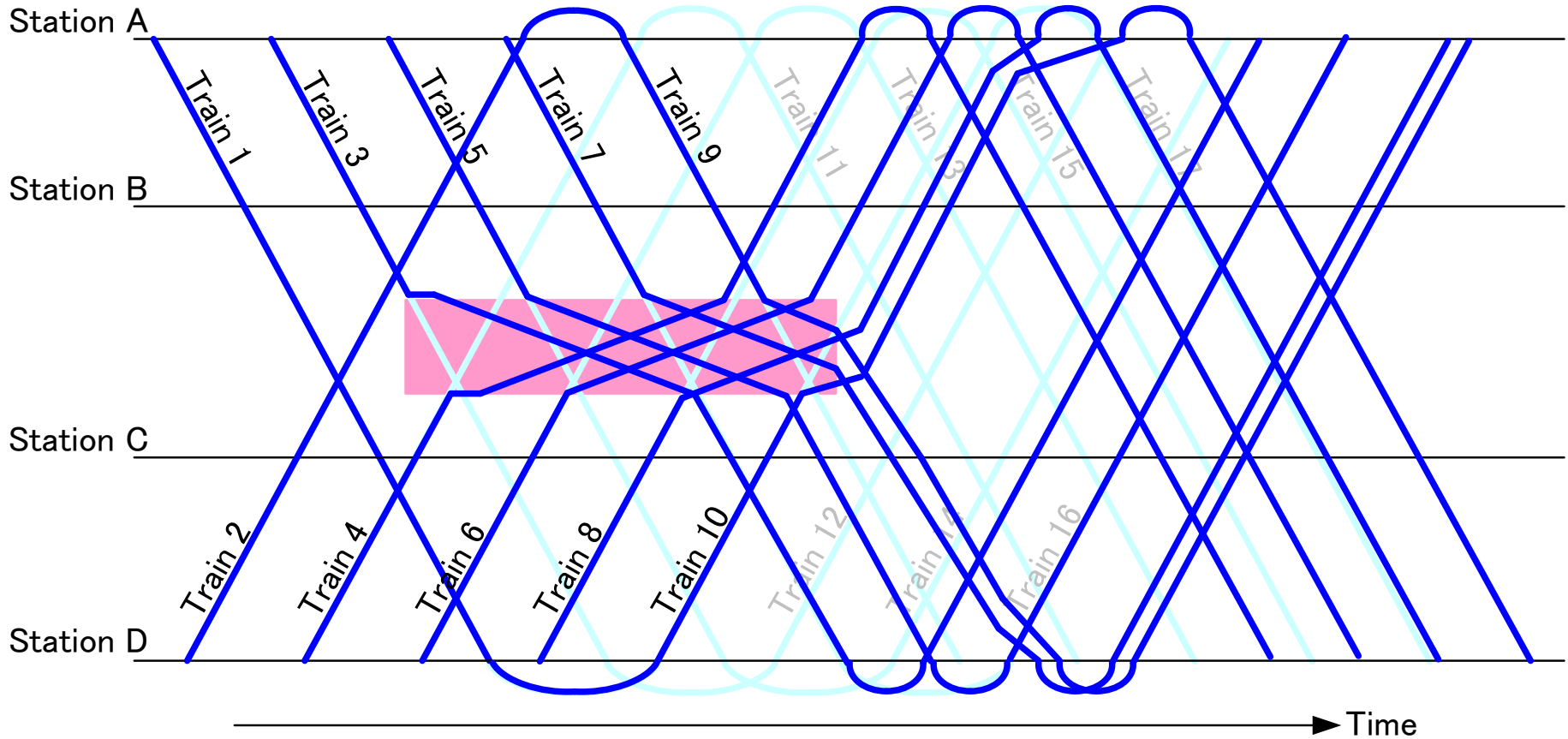
Delay caused by speed restriction



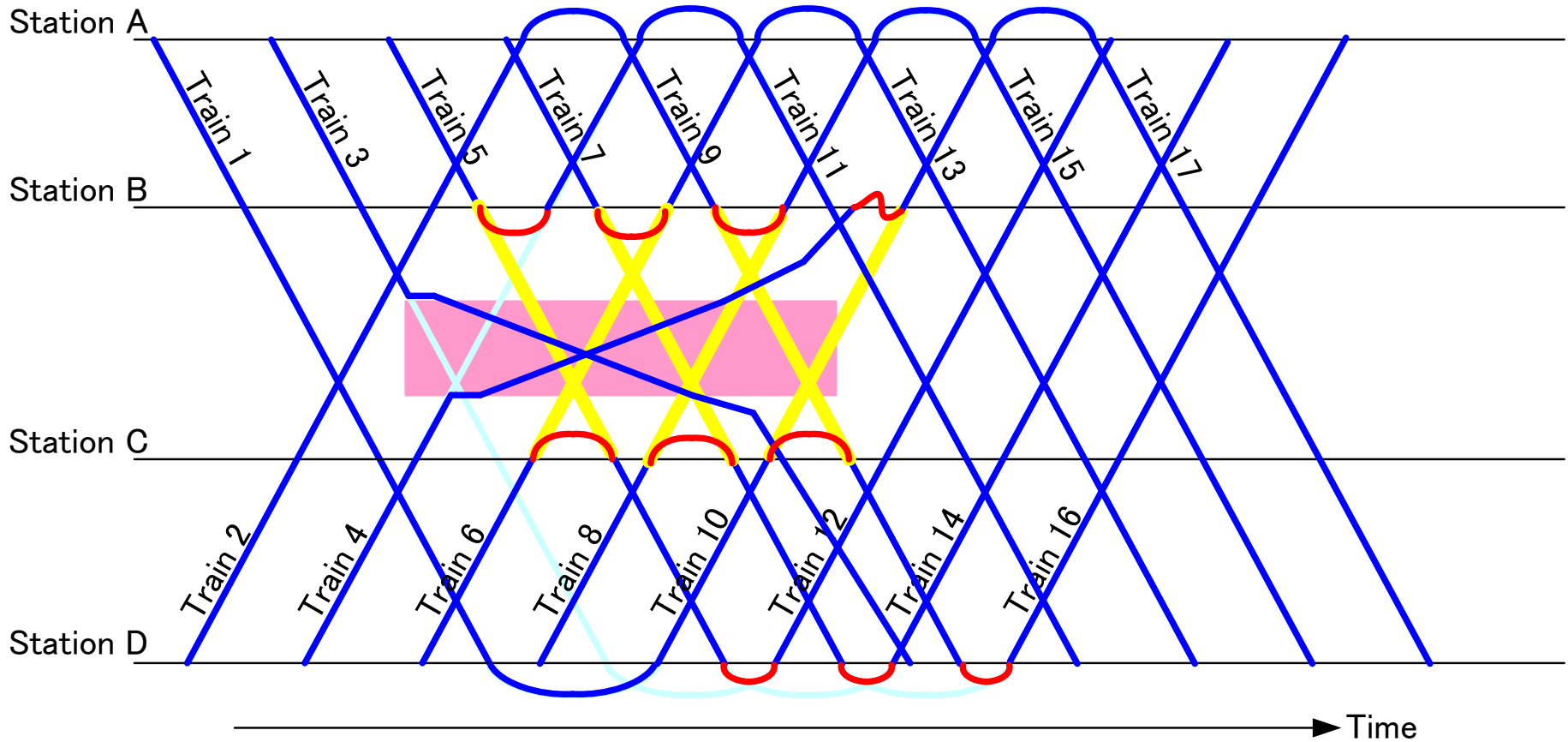
Under the speed restricted situation

- 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

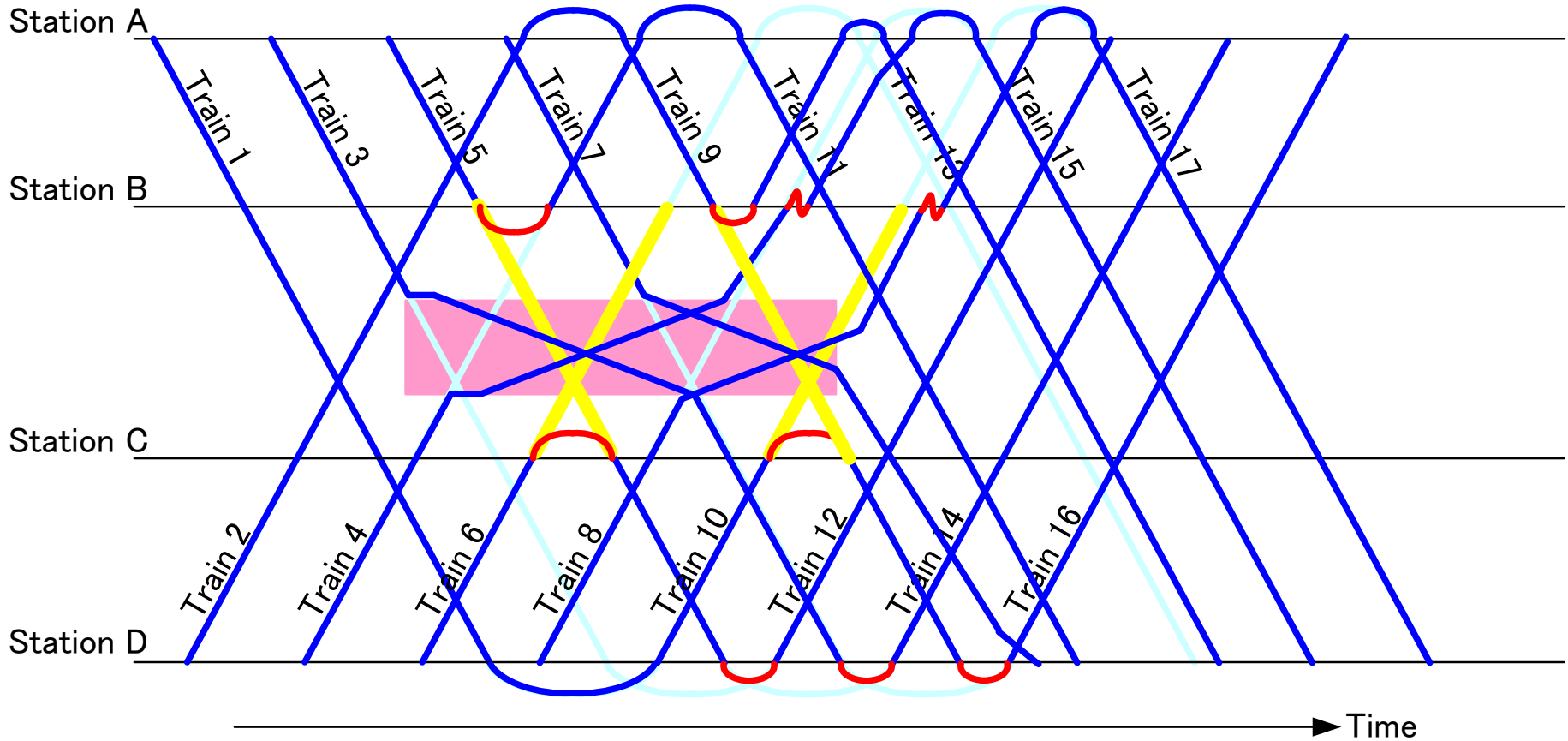
Delay caused by speed restriction



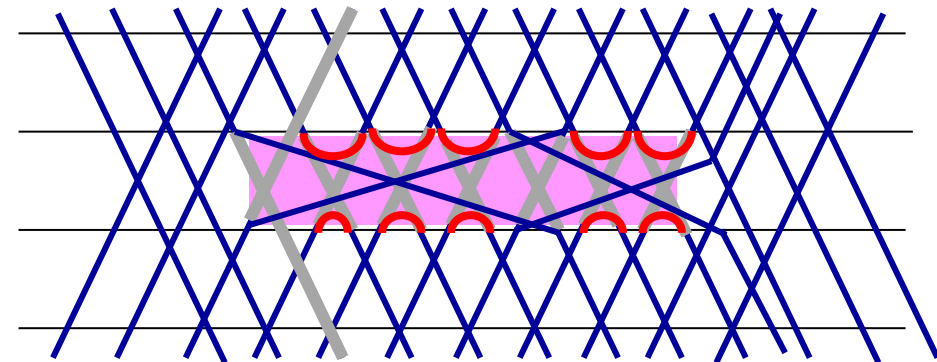
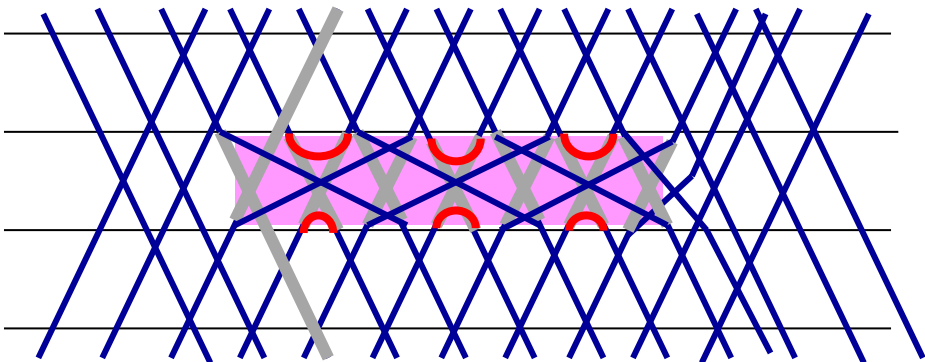
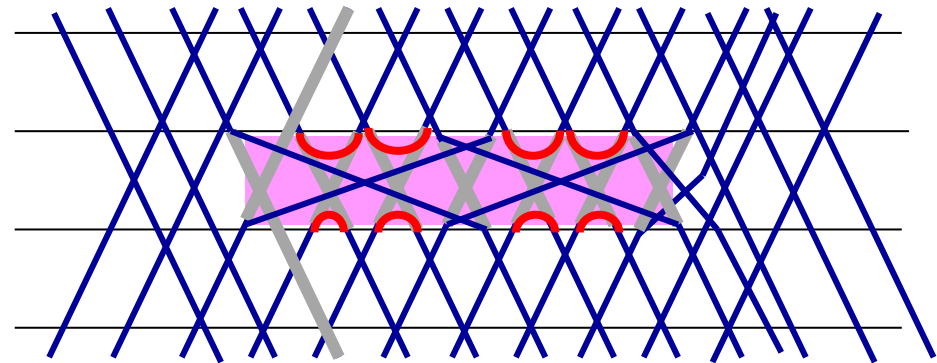
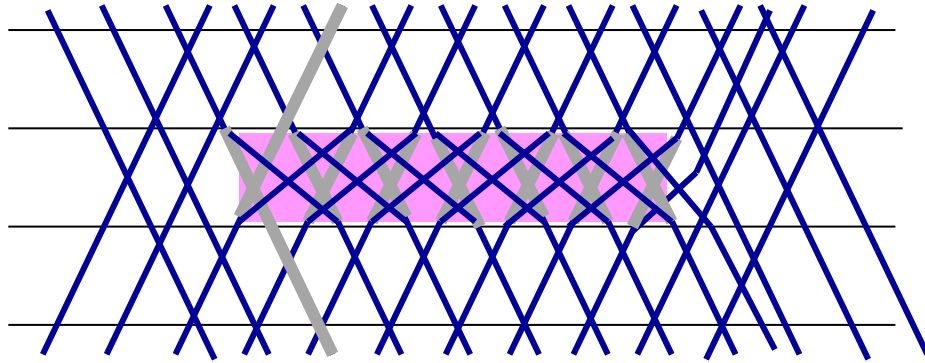
Cancelling all trains at the restricted section



Cancelling every other train



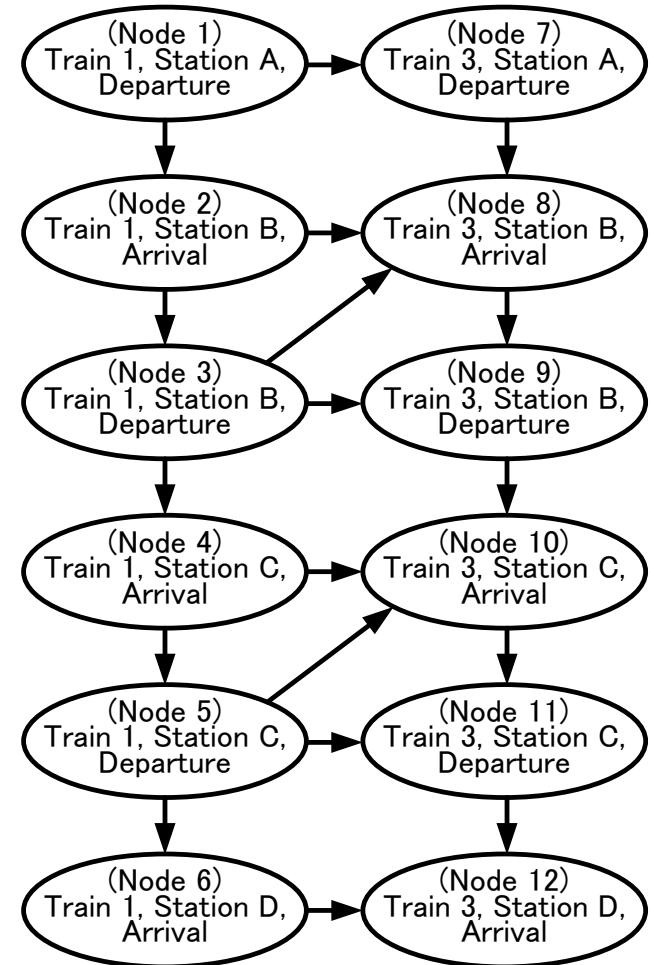
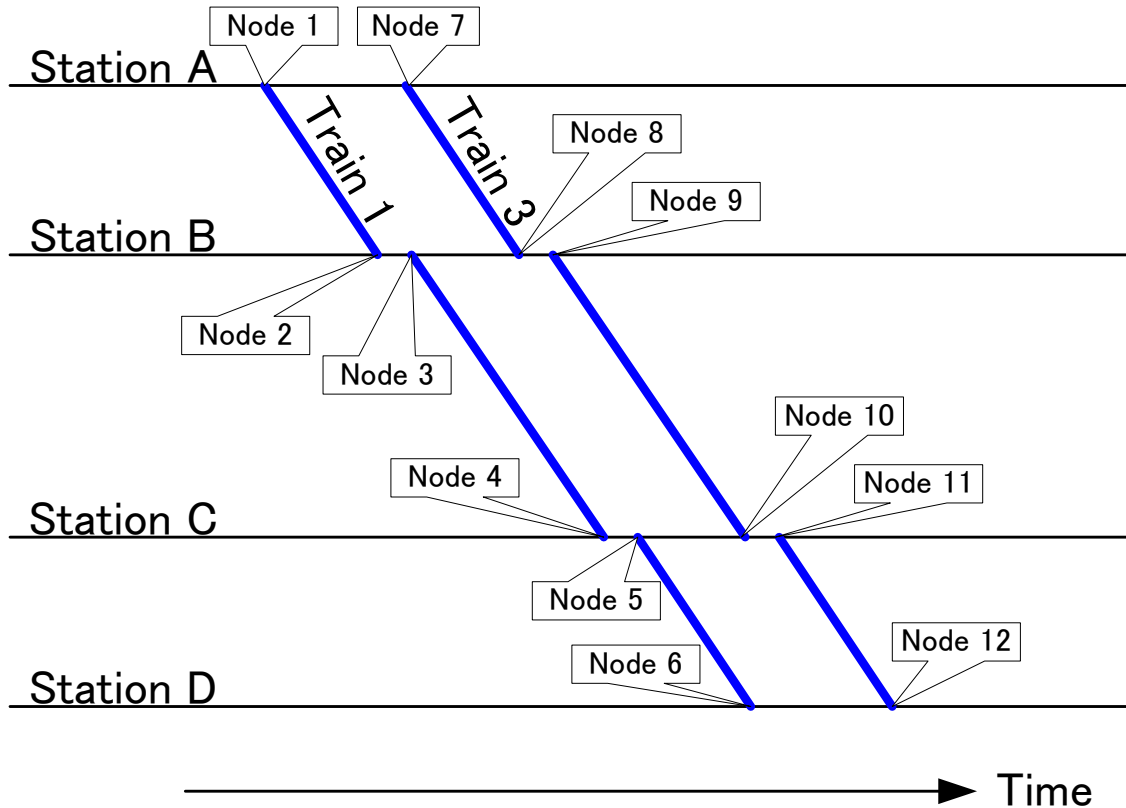
Cancellation pattern examples



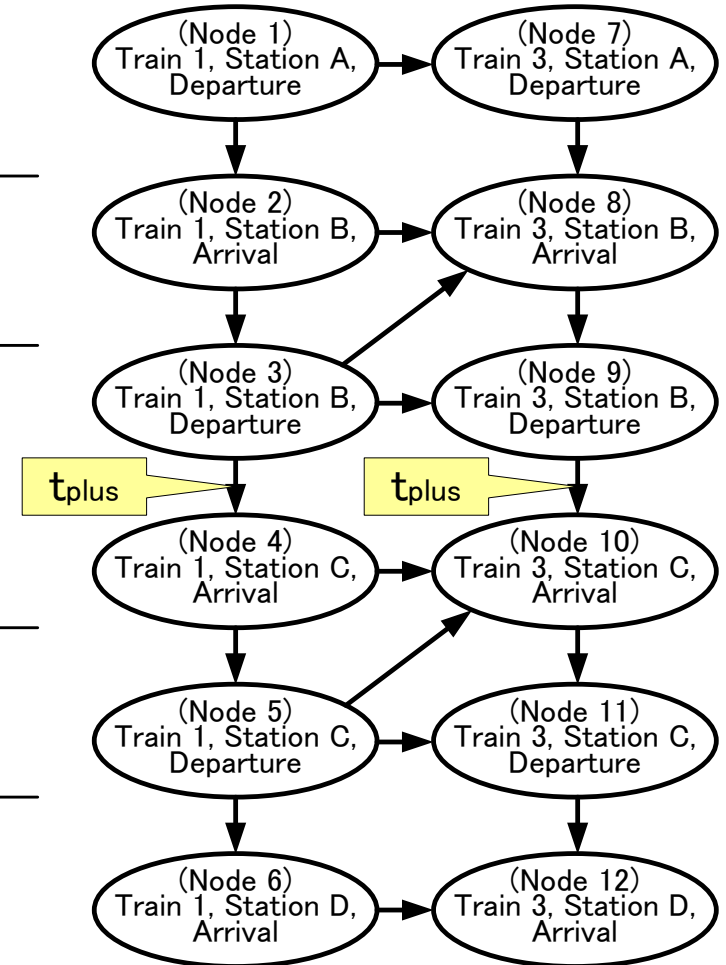
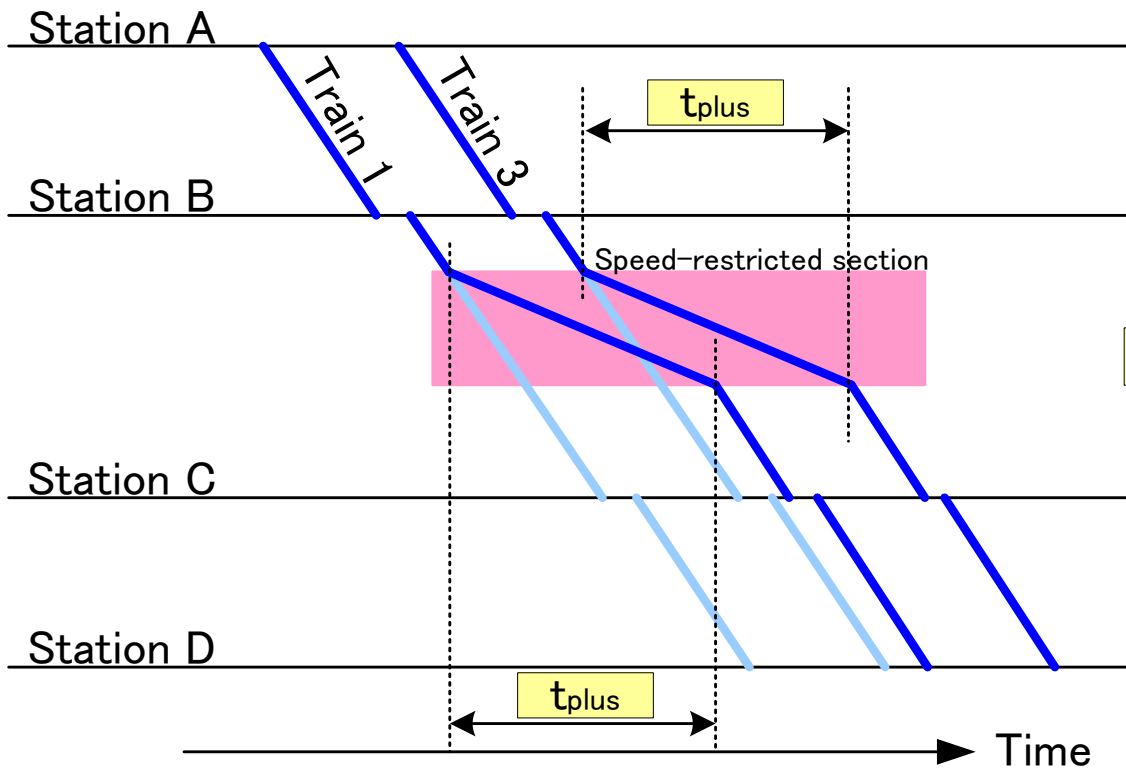
A simulation technique

- 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



A simulation technique with extra time



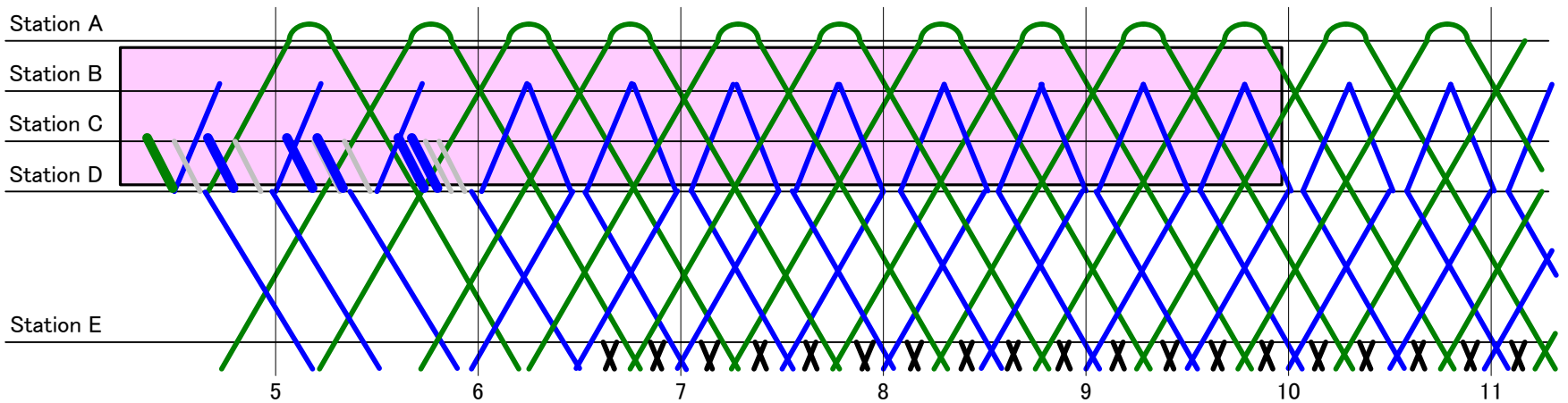
Evaluation measures

- 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

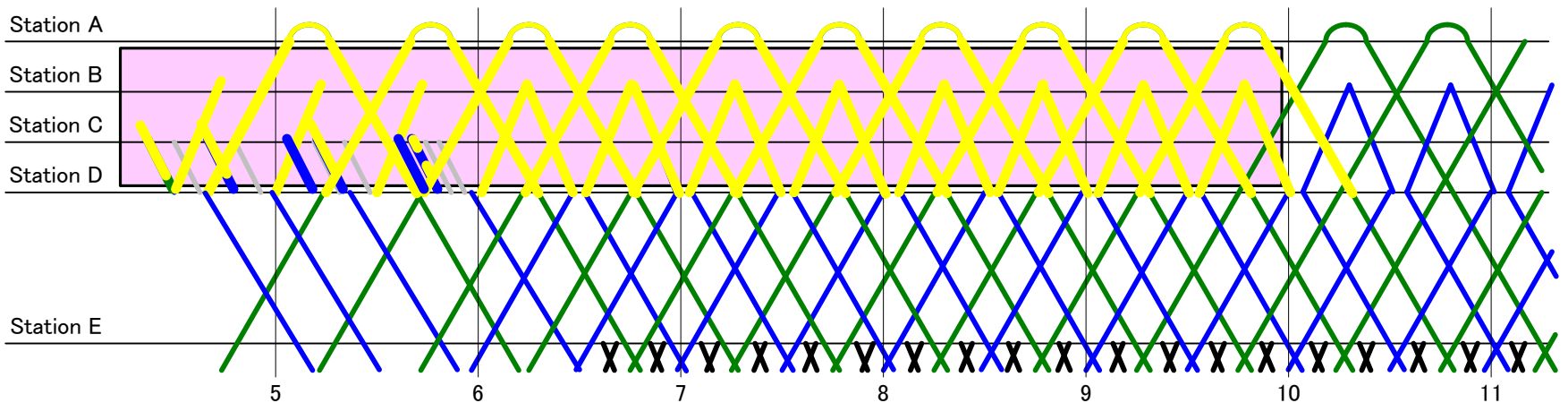
Case study

- 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

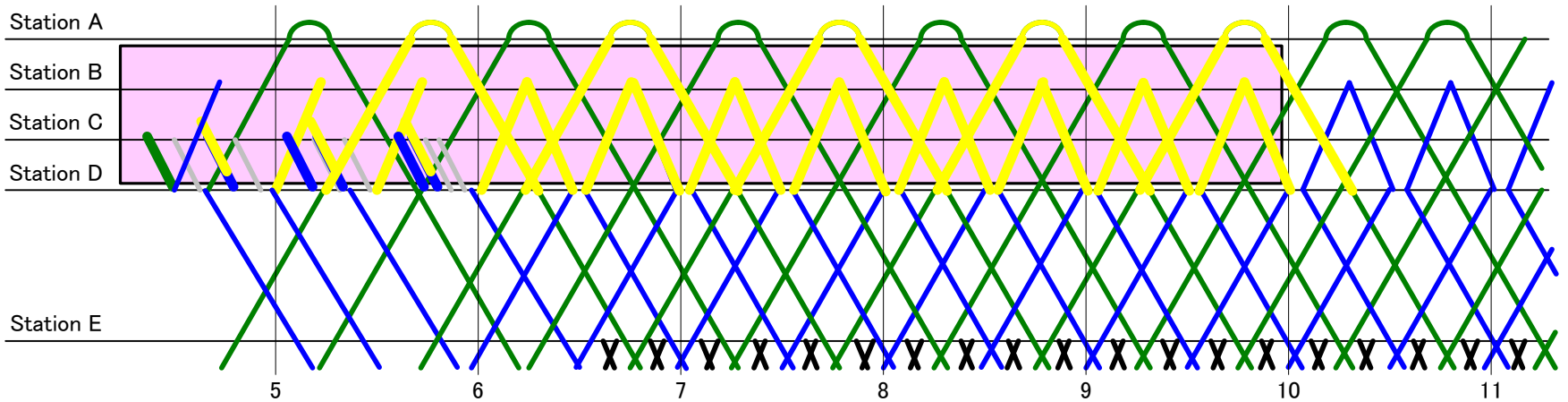
Plan 1: Small modification



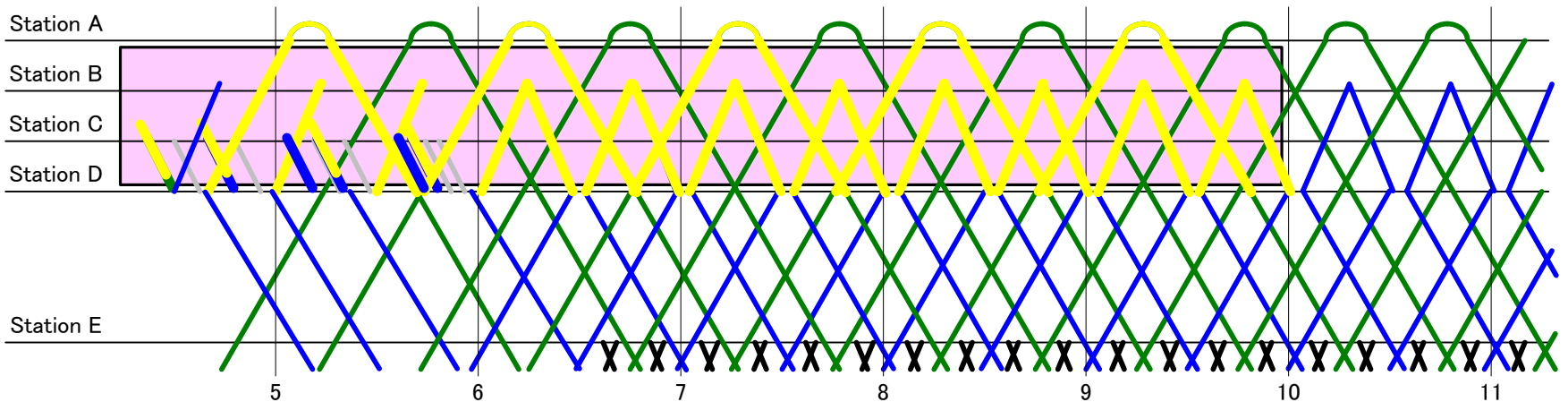
Plan 2: Cancelling all trains



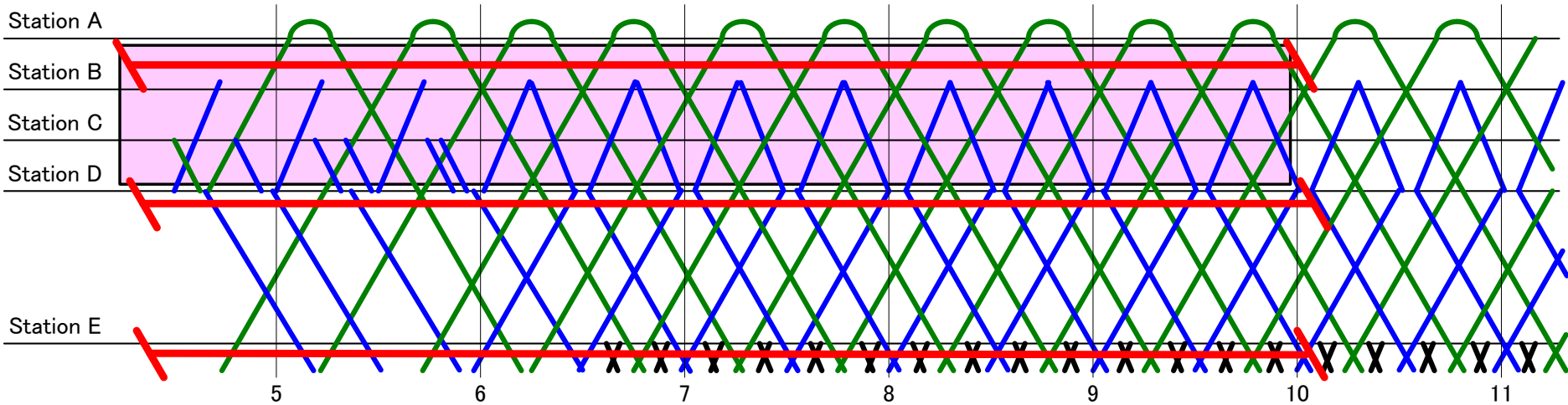
Plan 3: Cancelling every other train



Plan 4: Cancelling every other trains



Ratio of variance values



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

	Plan 1	Plan 2	Plan 3	Plan 4
Station A	0.9	-	1.7	3.0
Station D	7.8	1.0	4.0	4.4
Station E	3.0	1.0	1.3	1.2

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