November 29 2018
3rd Workshop on Railway Operation for Safety and Reliability at CityU

How to Plan and Manage Timetables with Skip-stop Operation More Efficiently

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Skip stop operation with coupling of rapid and regular trains work very well.

What we have to be careful about for skip stop operation?

New timetabling procedure considering running speed of trains.

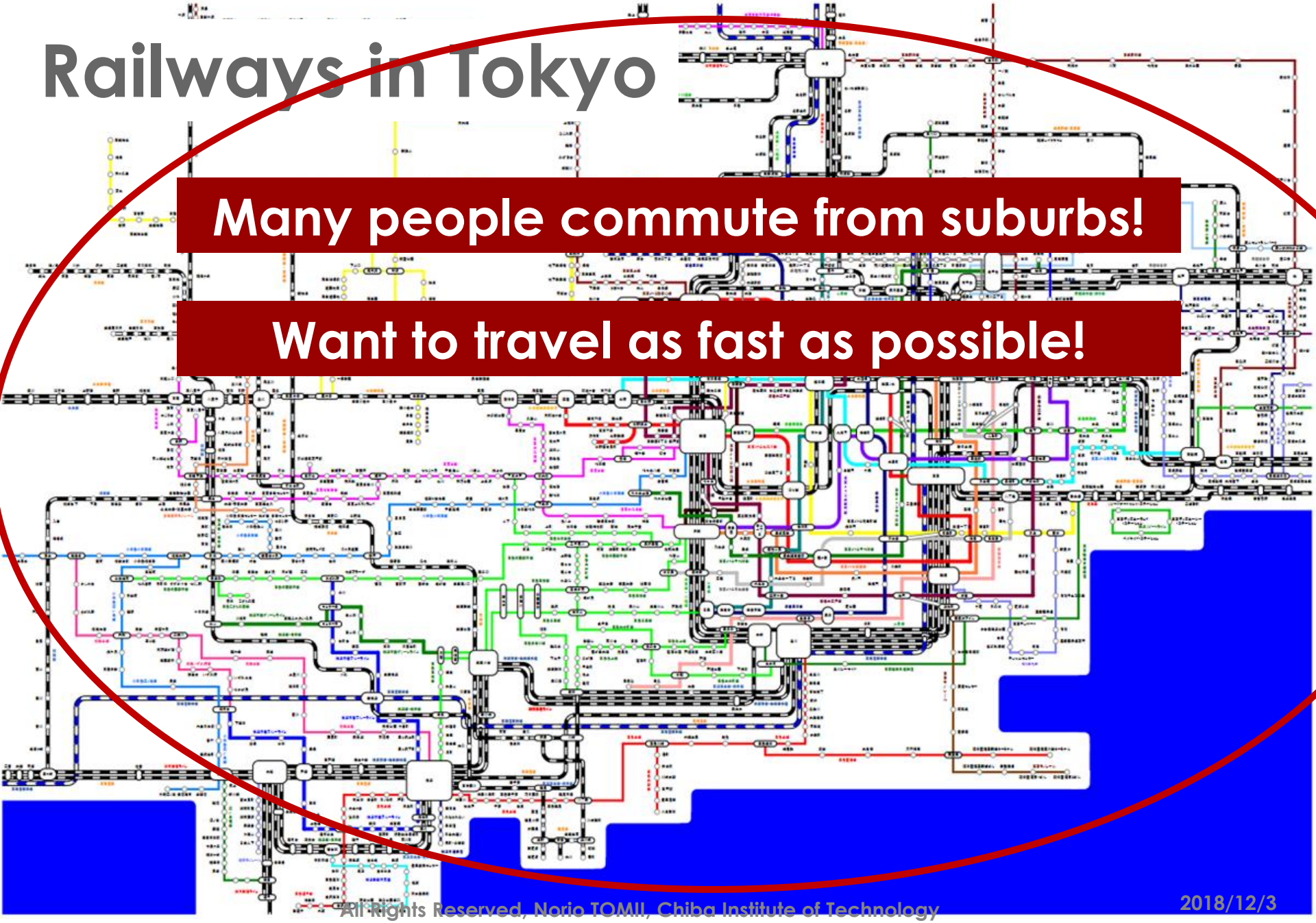
Who am I?

- Japan National Railways
  - Timetabling, Train Traffic Control System
- Railway Technical Research Institute
  - Scheduling Algorithms of Railway Operation
- Professor of Chiba Institute of Technology
  - Department of Computer Science

- Japan Transport Safety Board, ex-member
- President of IAROR (International Association of Railway Operations Research)

Contents

Railways in Tokyo



2018/12/3

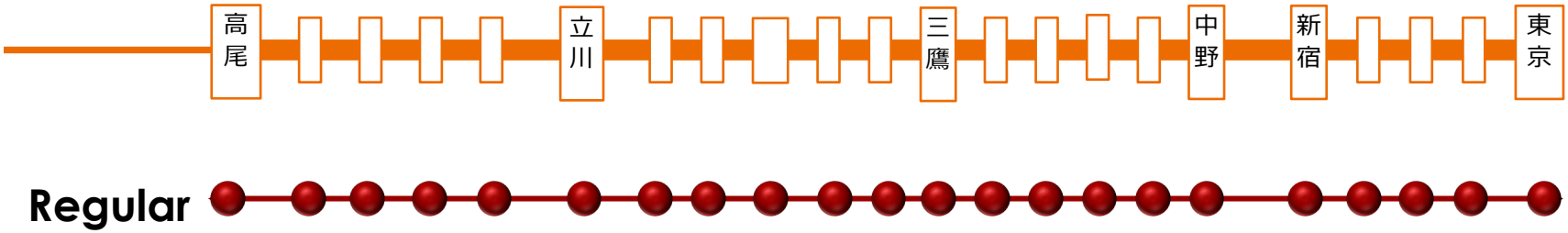
38 million!

Railway companies

- Seven JR companies
- Many private railway companies

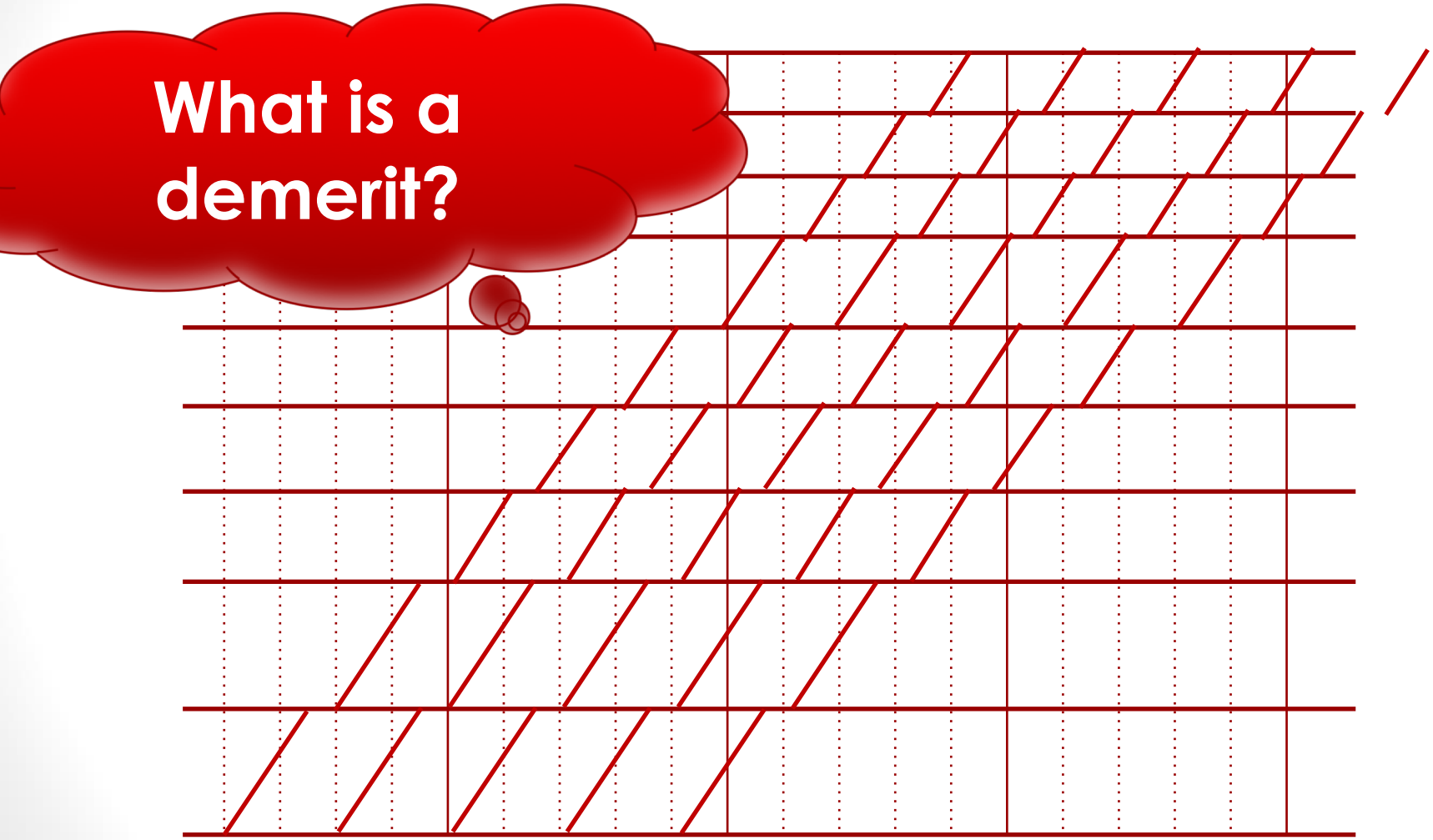
- They own infrastructure and operate trains
  - They do not receive subsidies
  - They have to spare investment
    - Not so many tracks, switches,…

What is a skip-stop operation?



- Regular train: stops at all the stations

Regular trains only!

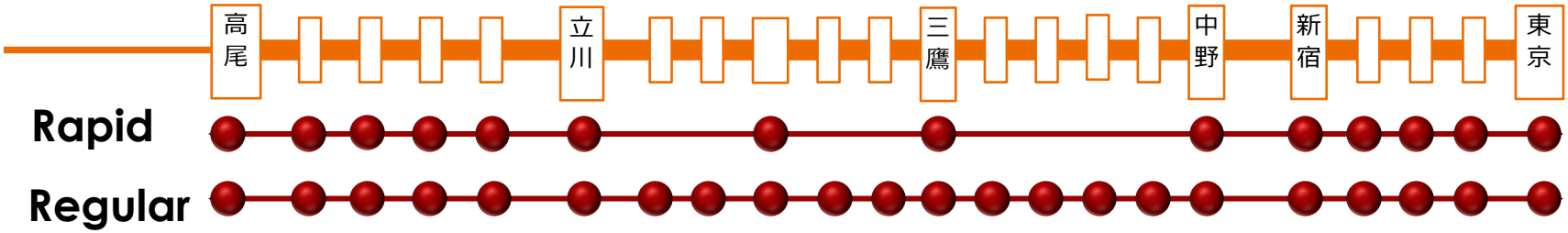


Too much time!

- There exist a lot of stations.
- If a train stops at all the stations?

Railway	From	To	distance
Keikyu	Shinagawa	Yokohama	0.93 km
Tokyu	Shibuya	Yokohama	1.21 km
Odakyu	Shinjuku	Mukogaoka	0.88 km
Keio	Shinjuku	Chofu	0.91 km
Seibu	Takadanobaba	Kamishakujii	0.98 km

What is a skip-stop operation?

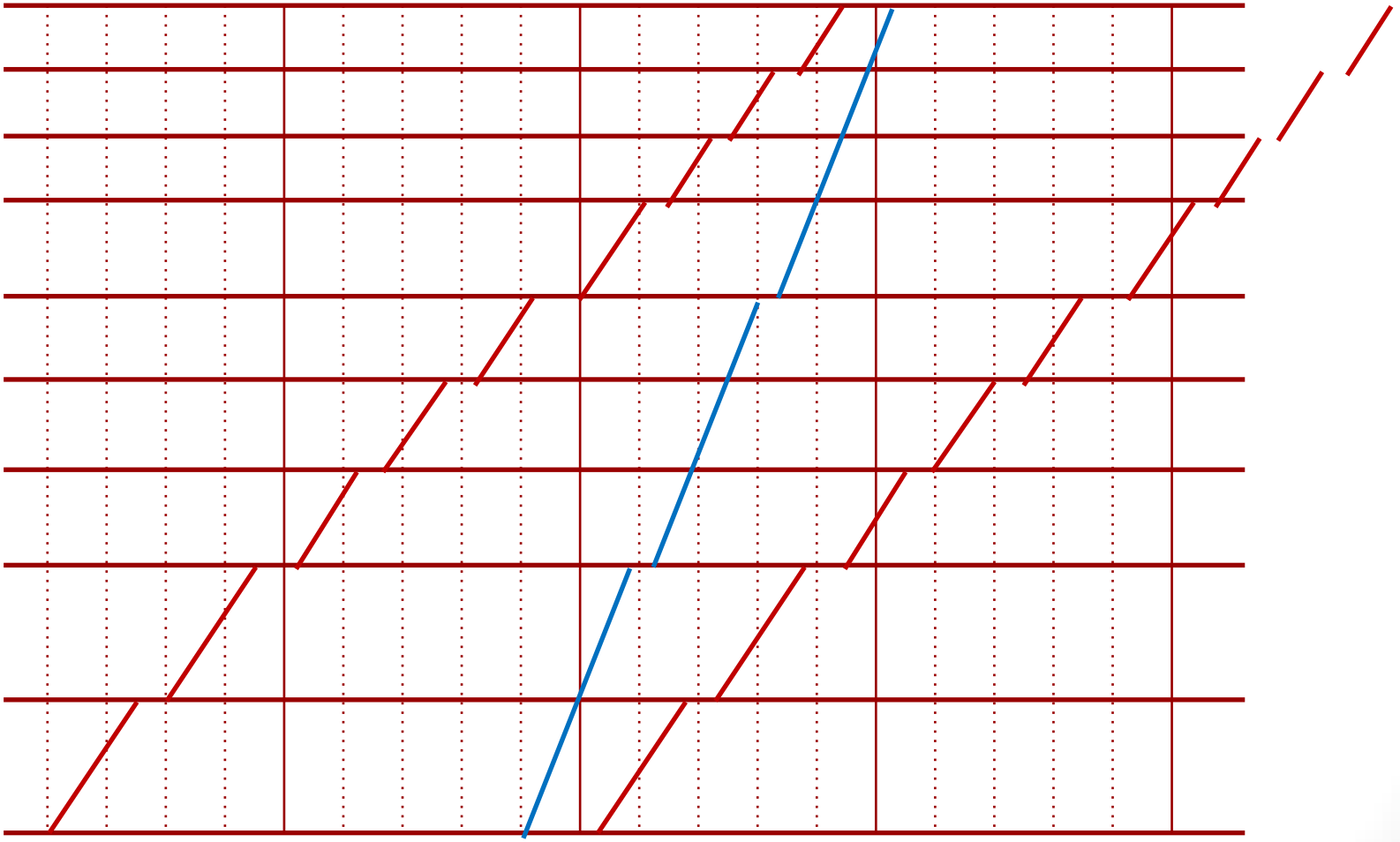


- Regular train: stops at all the stations
- **Rapid train: skips some stations**

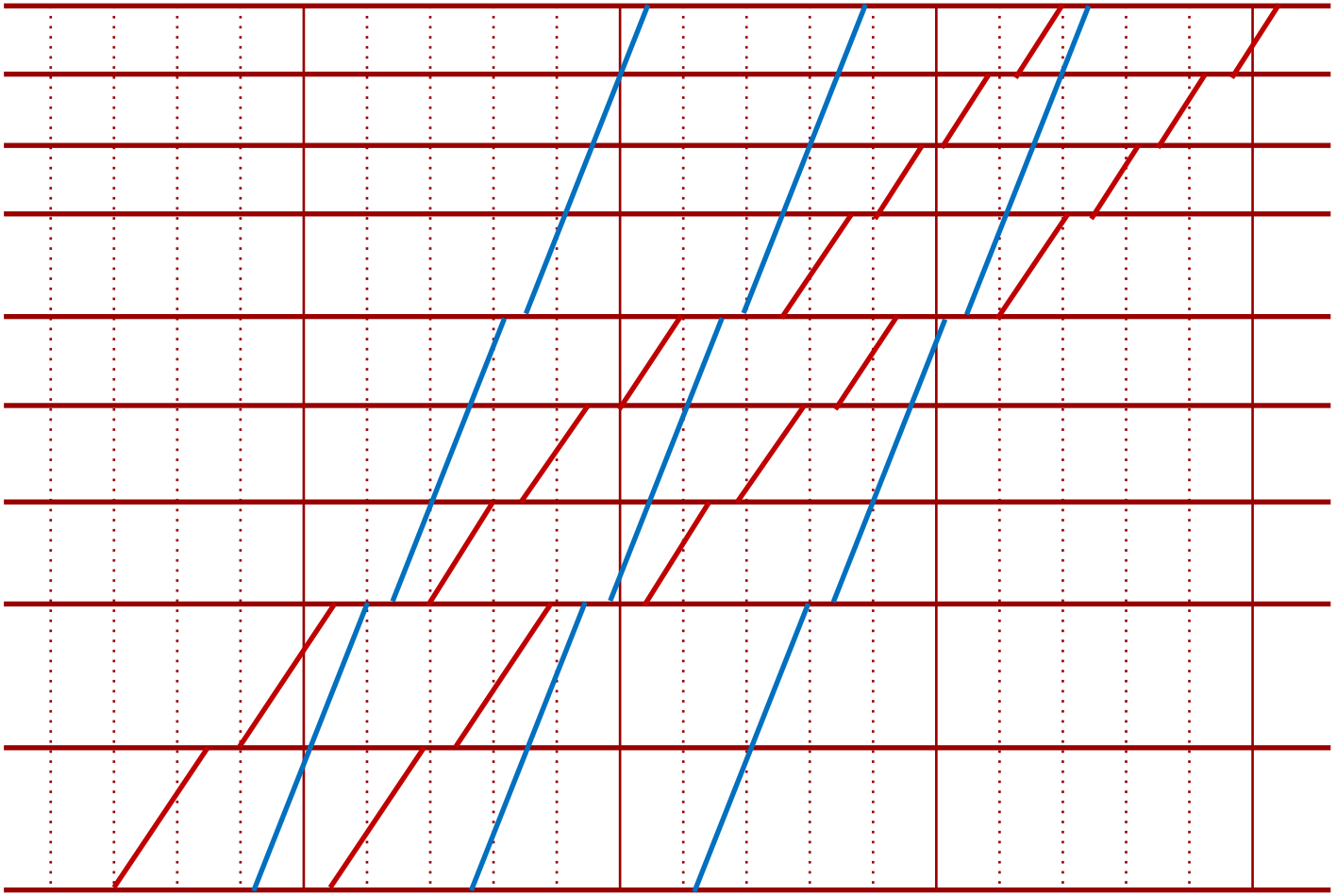
Why skip-stop operation?

Type	Journey Time	Stops
Regular	58 min.	25
Rapid	50 min.	17
Special	41 min.	8

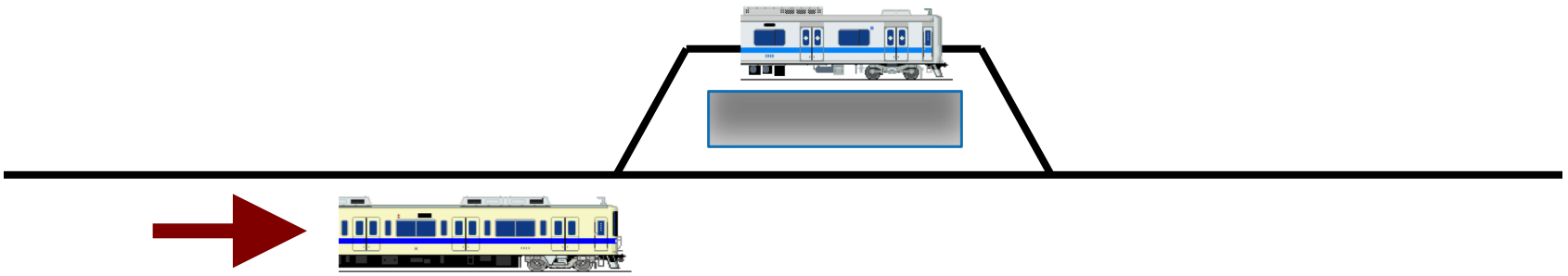
Less frequent?



Overtaking : more frequent



Transfer on the same platform



Coupling of rapid train and regular train

Regular train is coming.

Coupling of rapid train and regular train

Rapid train is coming.

Passengers can transfer mutually on the same platform.

Coupling

- 81min. : by Regular
- 47min. : by Rapid+Regular

Contents

- When we operate skip-stop operation, we have to be careful for
  - **Congestion**

We have to be careful for

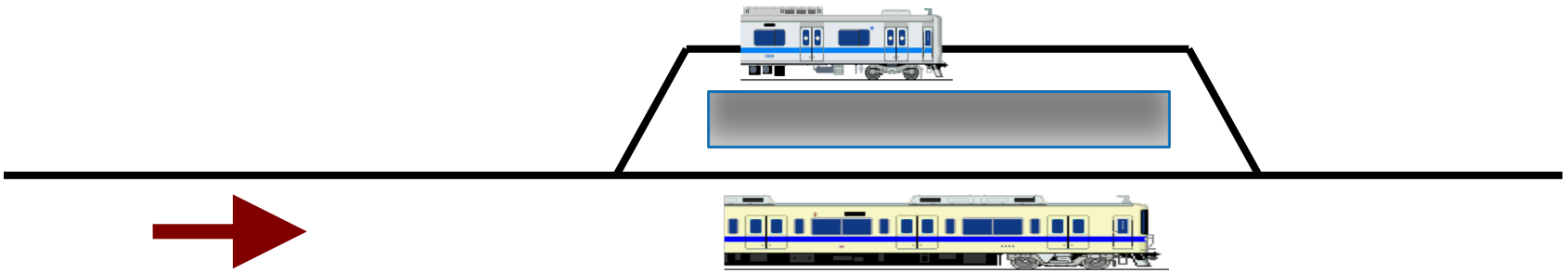
- Congestion of rapid trains
  - Dwell times of rapid train increase because a lot of passengers get on/off.
  - Delay occurs!

We have to be careful for

- Congestion of Rapid trains

- Solutions
  1. Longer train-set for rapid trains
     - Complicated…

Longer train-set for rapid trains?



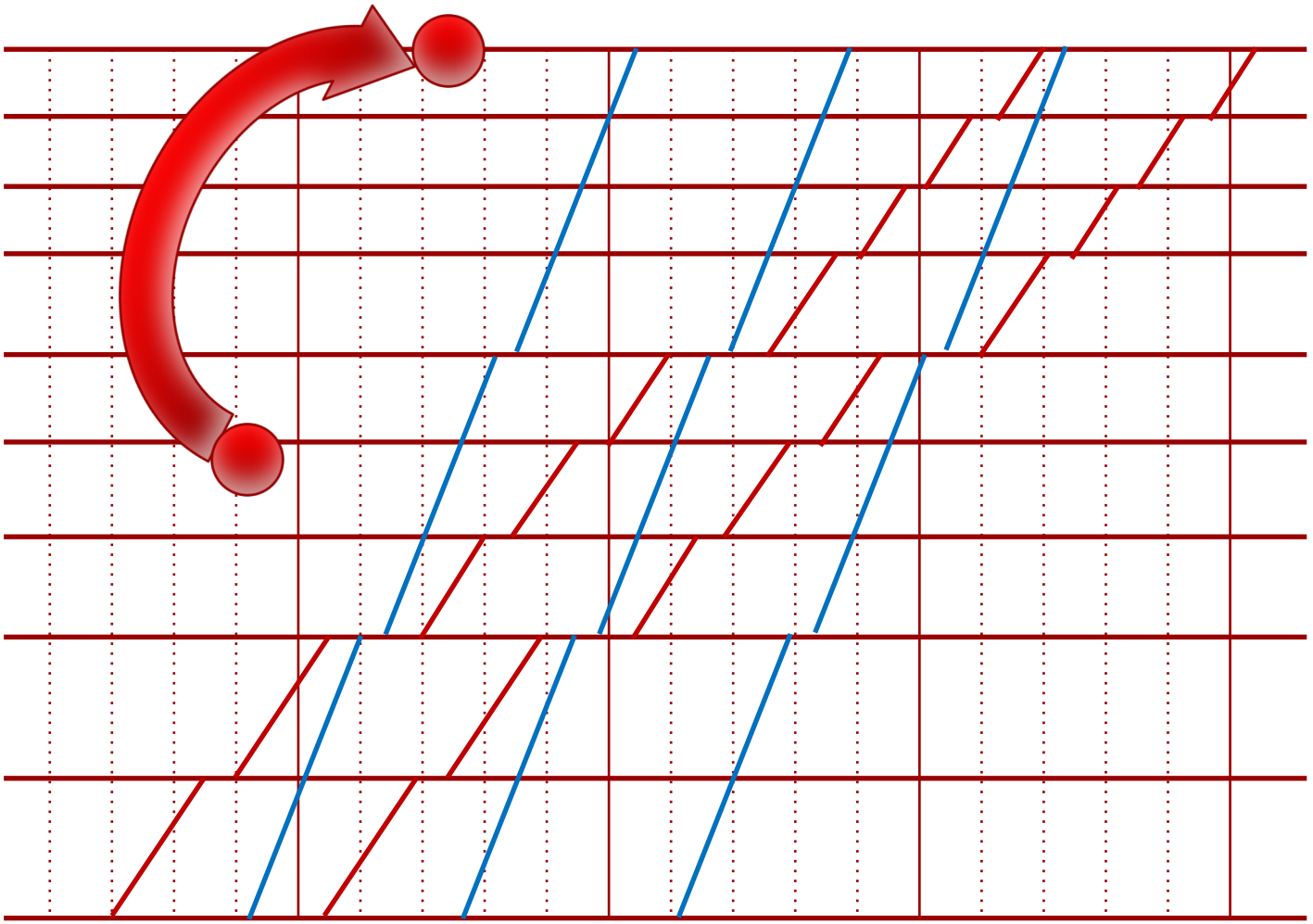
If rapid trains are longer?

We have to be careful for

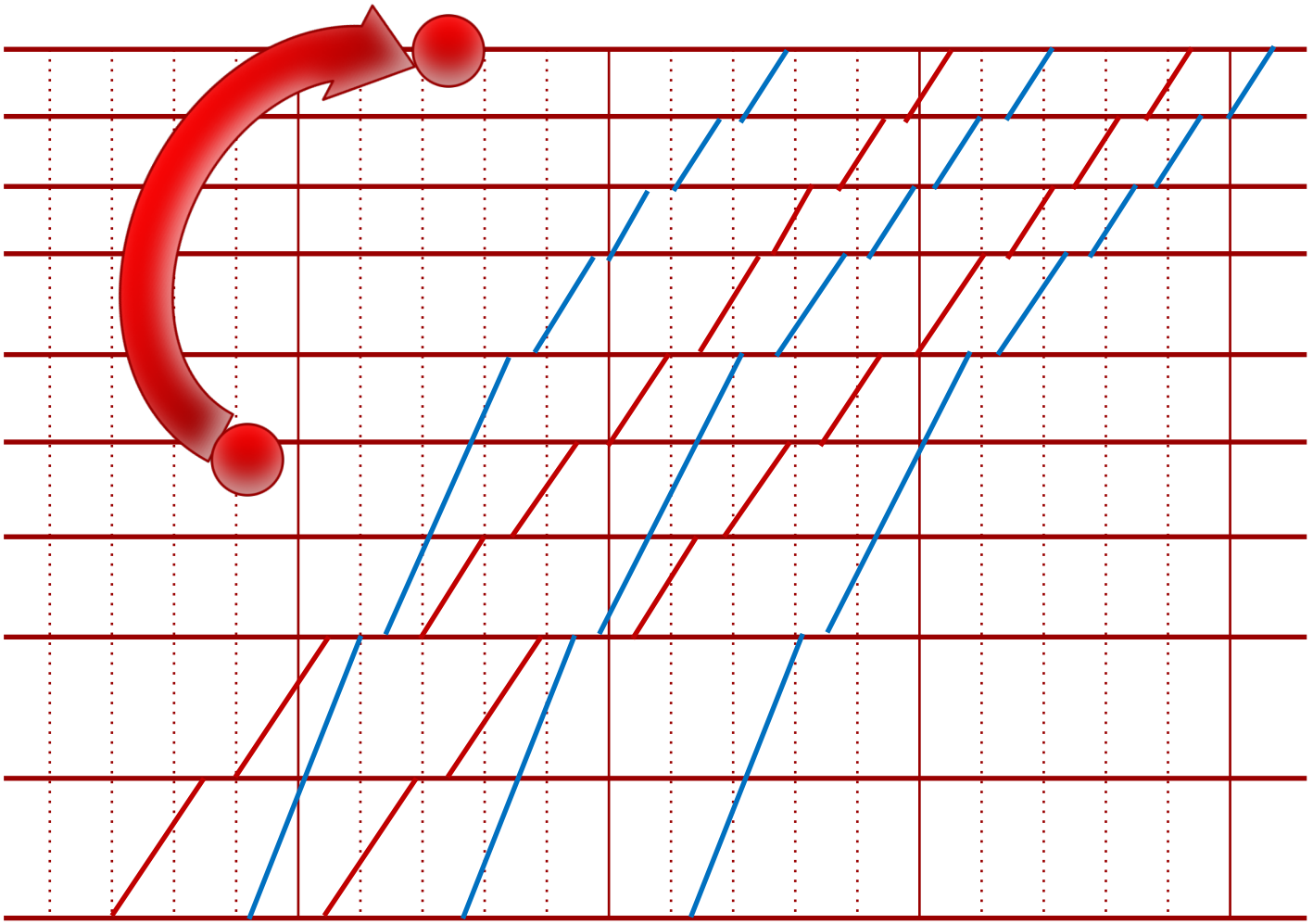
- Congestion of Rapid trains

- Solutions
  1. Longer train-set for rapid trains
  2. For certain areas, rapid trains stop at all stations and do not overtake rapid trains

Coupling of rapid train and regular train

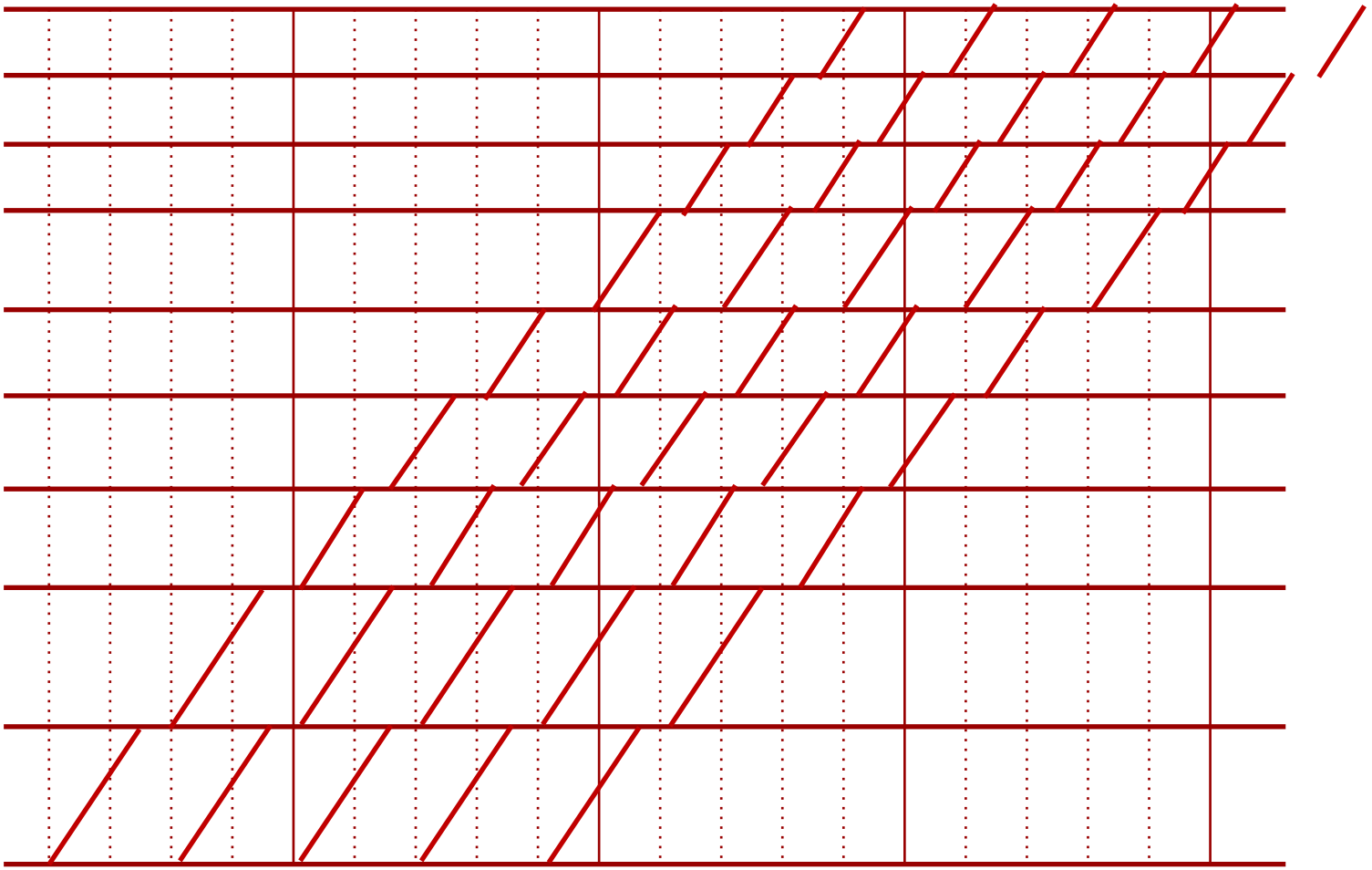


Rapid train does not overtake

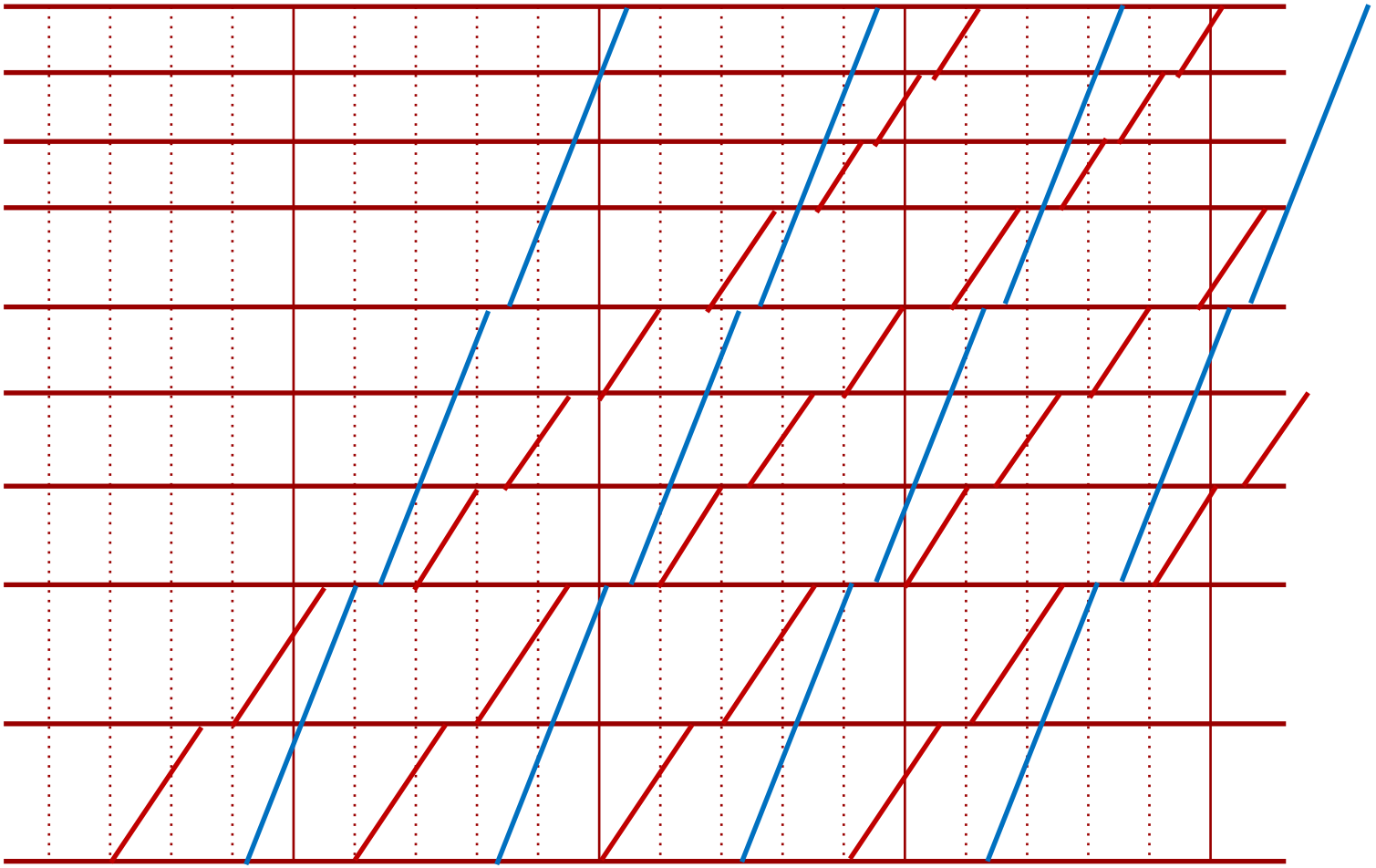


- When we operate skip-stop operation, we have to be careful for
  - Capacity

Regular trains only!



Overtaking

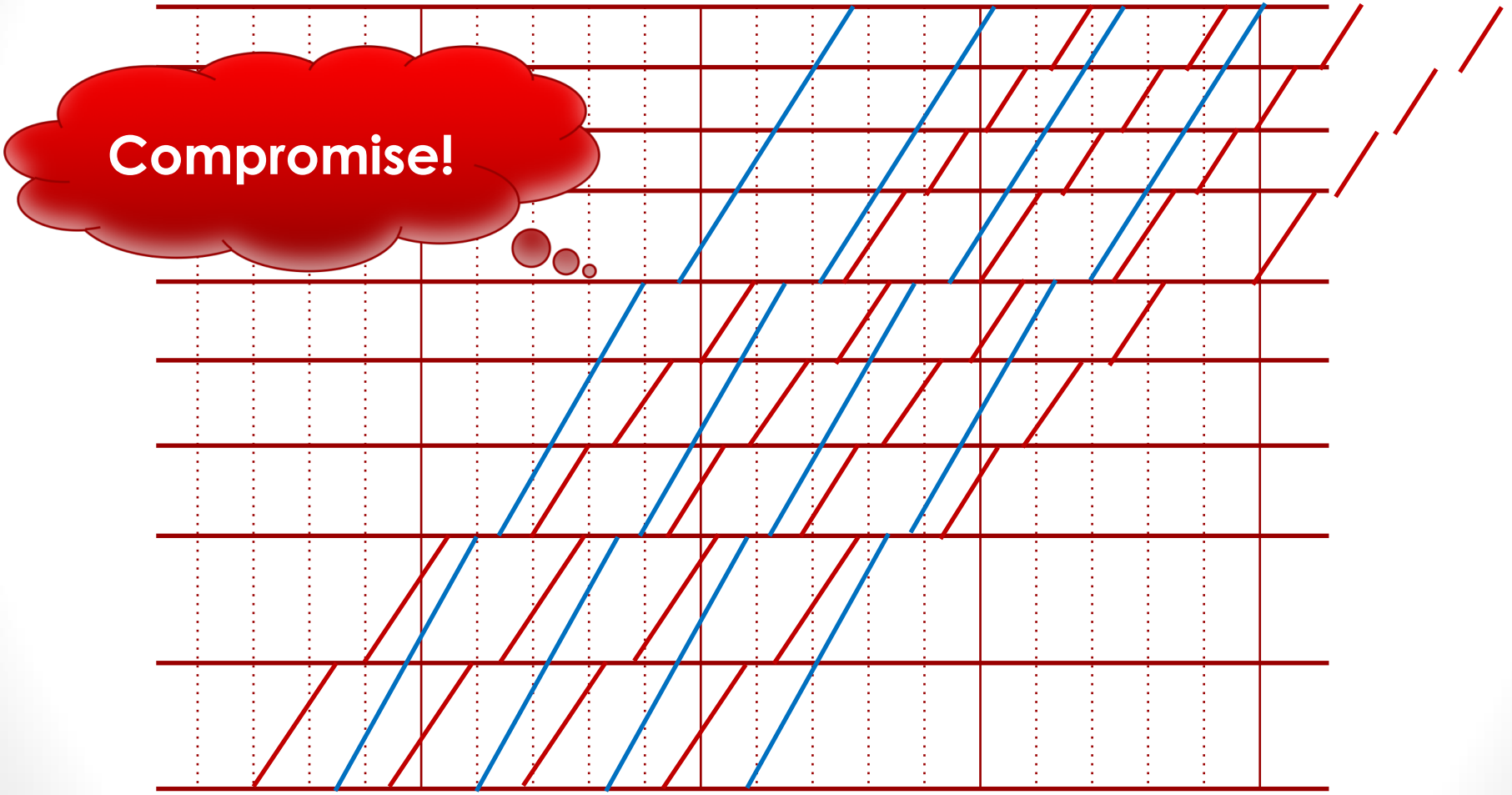


We have to be careful for

- Enough capacity during morning rush hours?

- Solution
  1. Decrease running speed of rapid trains

Rapid trains run slowly

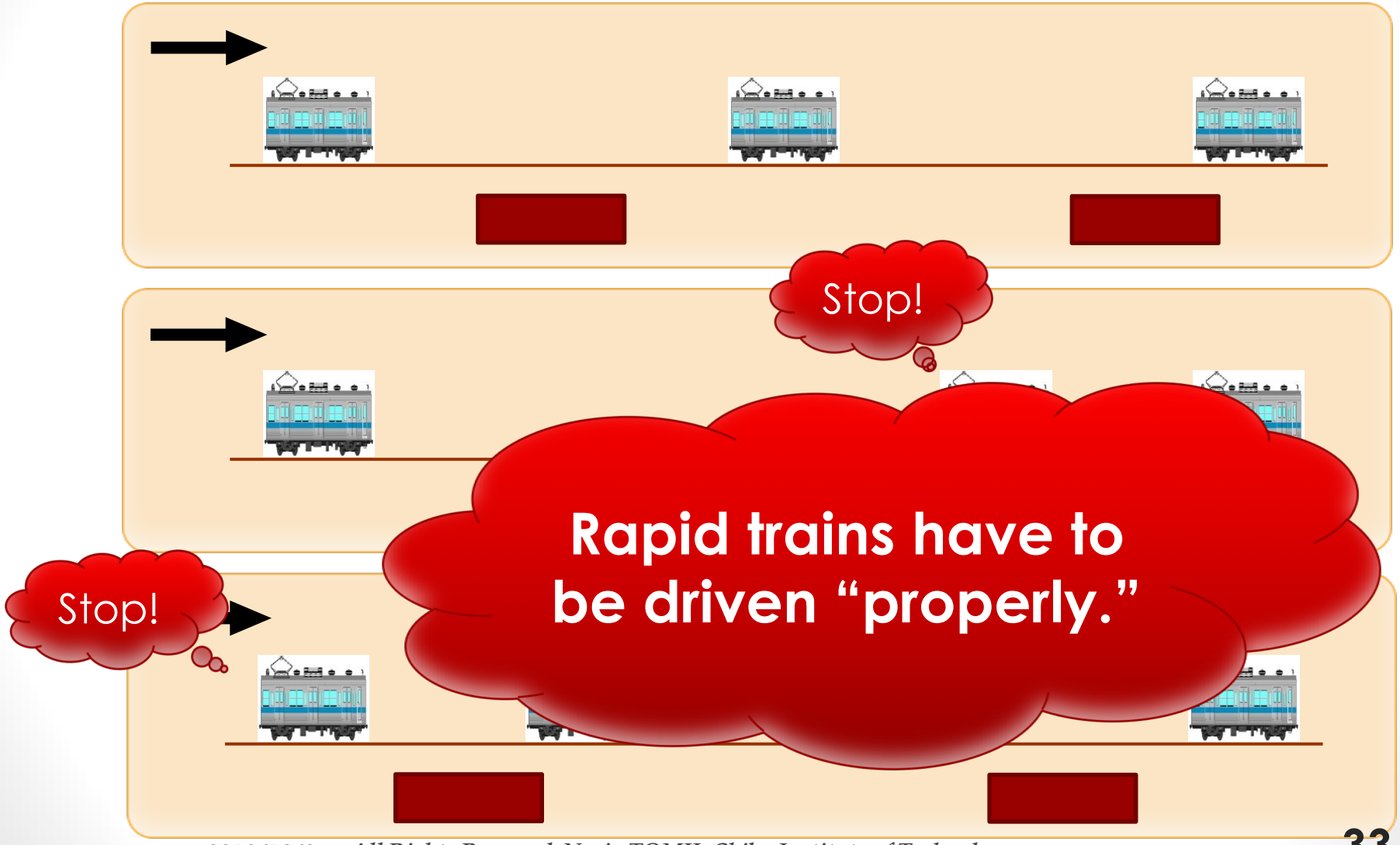


Rapid trains run slowly

- What we have to be careful about?

  - Rapid trains have too much **running time supplement**!
  - Drivers have too much freedom in driving!

Too much running time supplement – too much freedom



Contents

1. What is a skip-stop operation?
   1-1 Some examples
   1-2 Why skip-stop operation?
2. Considerations for skip-stop operation
3. New timetabling procedure considering running speed of trains
4. Results of applications

Issues

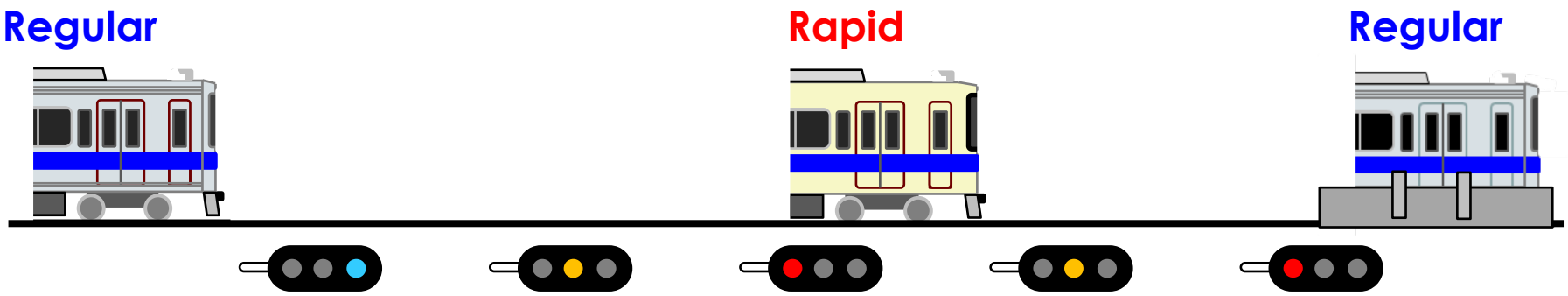
- Rapid trains have to run "**properly**"
- Otherwise **Delay !**
- **What we should do to let rapid trains run "properly"**

Our Ideas

- Our idea
  - specify departure / arrival times + **running speed** of trains in a **timetable**.
  - Brand new approach for **timetabling** !
- Conventionally,
  - Only **departure times and arrival times** are specified in a **timetable**

Our Ideas

- Speed information is shown to driver



- Planning phase! -> Static
- Not a DAS!

Problems to be solved

1. How we can **specify** the running speed?
2. How we can **calculate** the appropriate running speed?
3. How we can let the drivers **know** the running speed?
4. Drivers can really **follow** the specified running speed?
5. What we should do in case of (somewhat) **large delays**?

Problems to be solved

1. How we can **specify** the running speed?
   - Divide the track between main stations into several **sections**.
   - Define the speed limits for each section

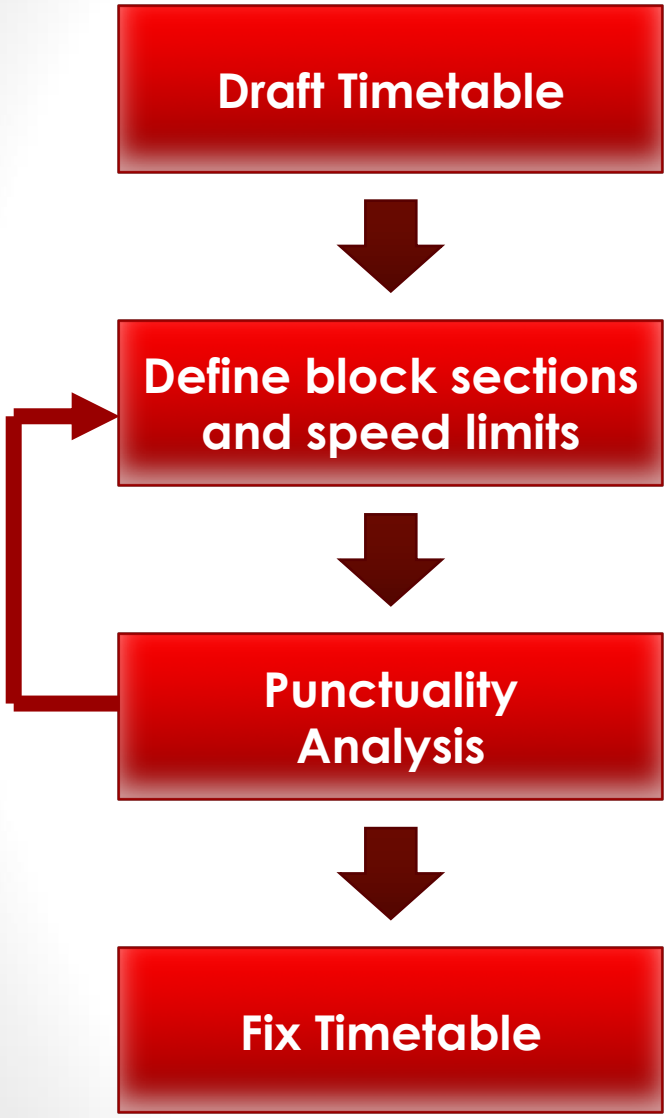
	Section	Speed limits
Sta.1 – Sta.5	Section A	No Limit
	Section B	XX km/h
	Section C	XX km/h

Problems to be solved

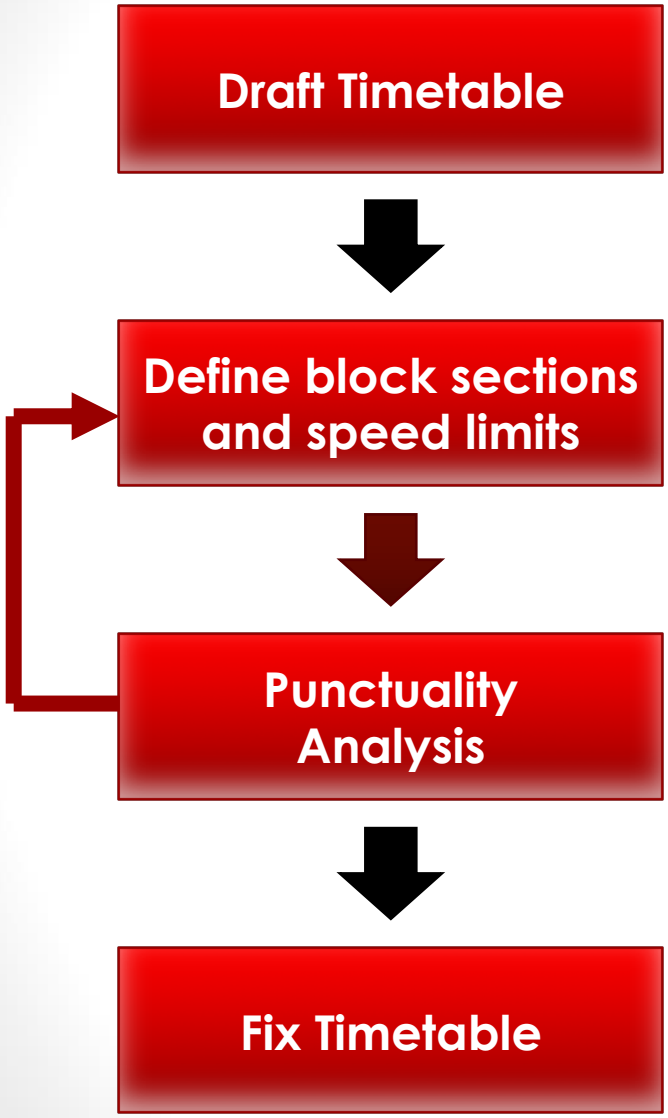
2. How we can **calculate** the appropriate running speed?

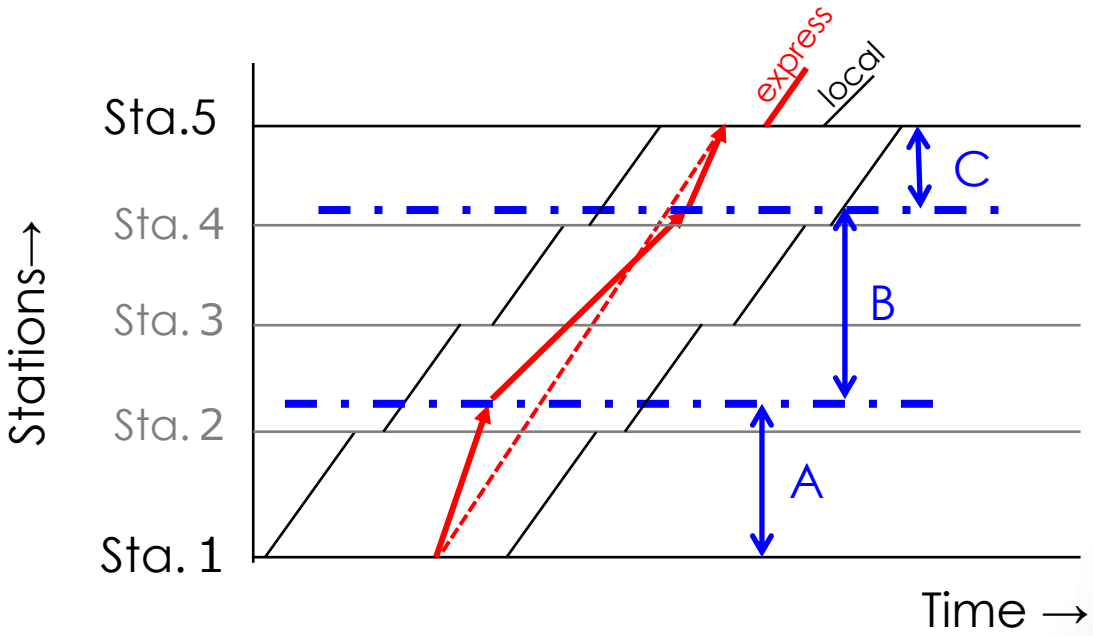
- microscopic simulation
- iterate simulation & check

Algorithm of new approach

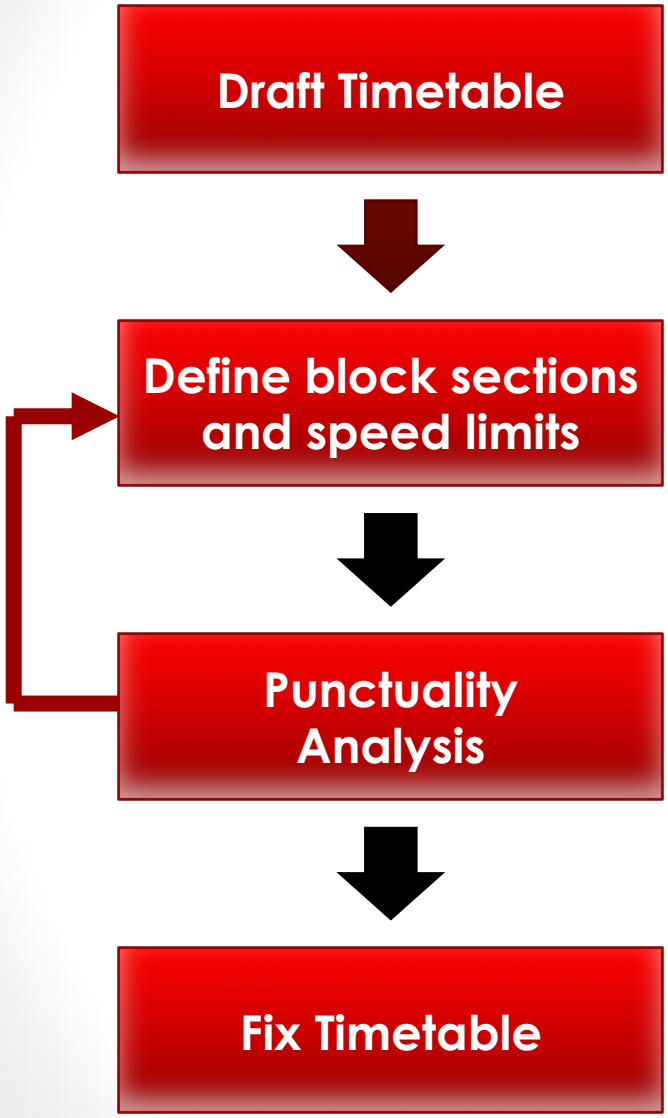


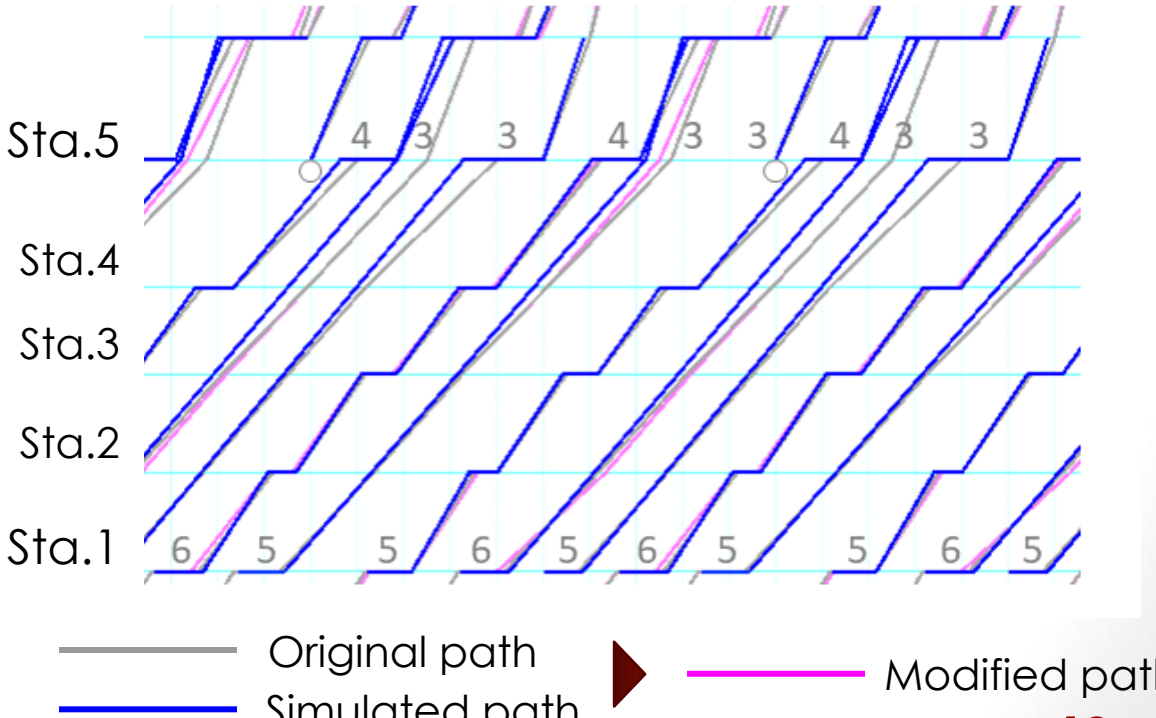
Algorithm of new approach





Algorithm of new approach





Algorithm of new approach

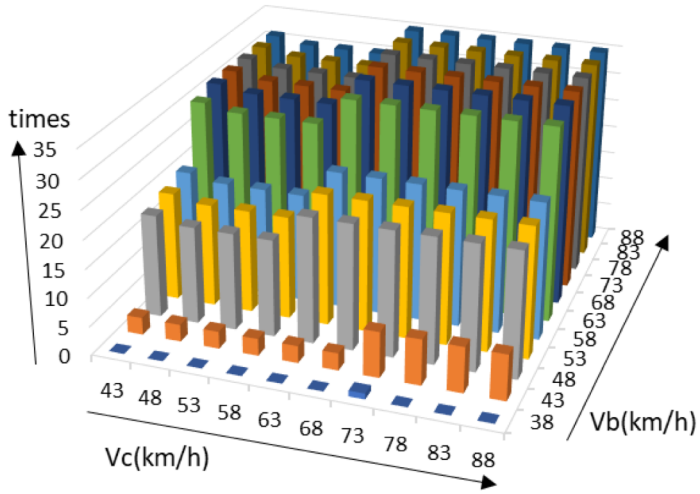
Draft Timetable

Define block sections and speed limits

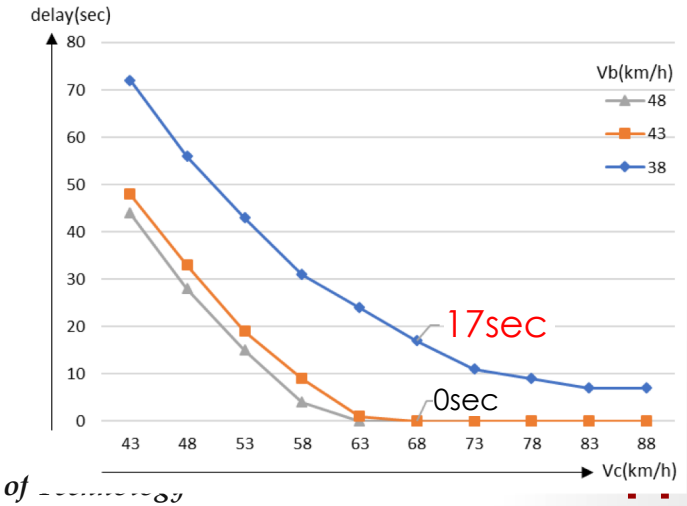
Punctuality Analysis

Fix Timetable

Times of stop between stations



Maximum arrival delay at Sta.X



Problems to be solved

3. How we can let the drivers **know** the running speed?

We list the information on Drivers' timetable cards!

Problems to be solved

4. Drivers can really **follow** the specified running speed?

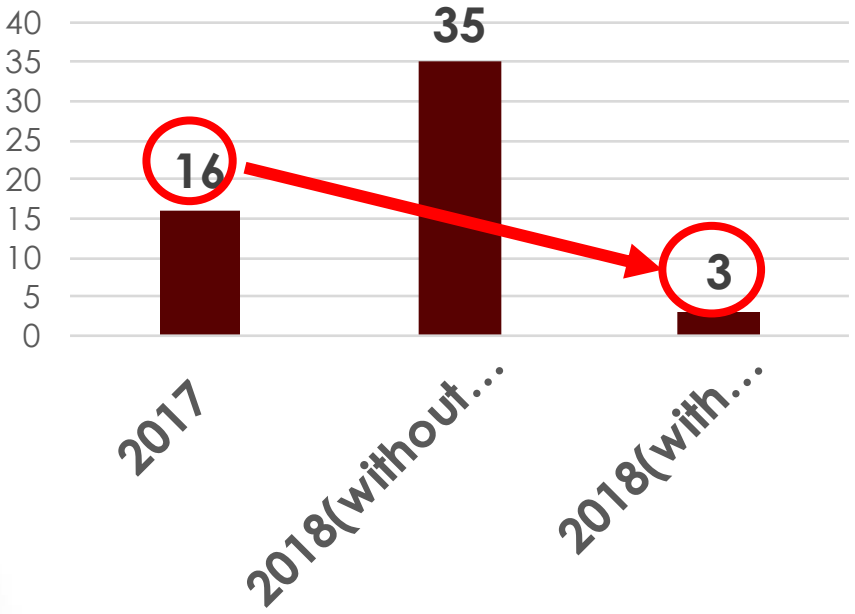
Problems to be solved

5. What we should do in case of (somewhat) large delays?

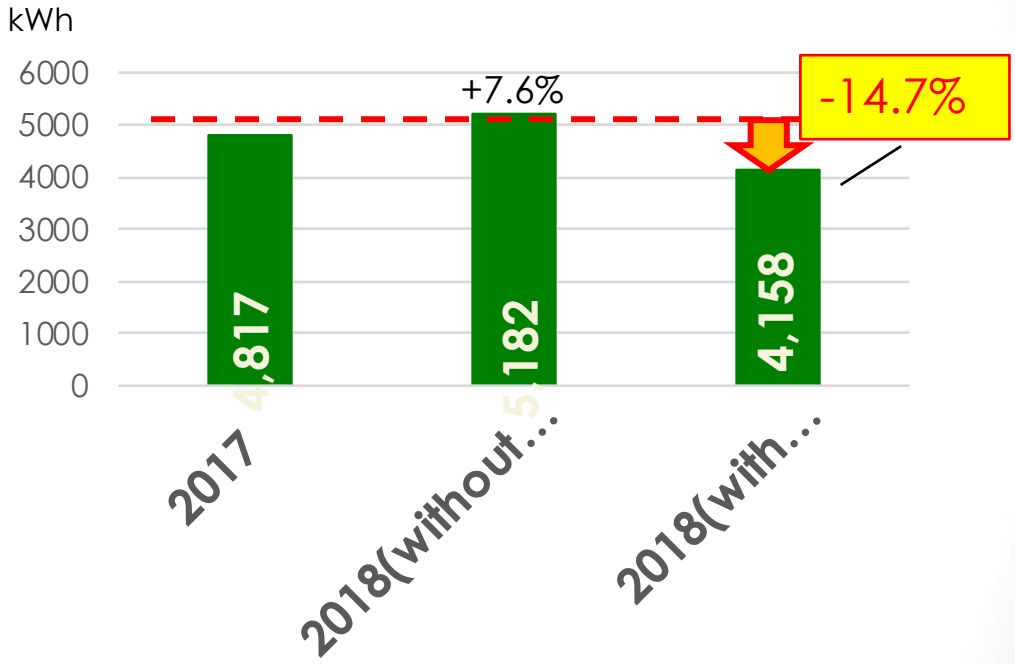
- cancel the speed limit in order to recover the delay.
- dispatcher of OCC makes a decision and gives an order.

Simulation results

Times of stop between stations



Energy consumption for acceleration



Condition
All trains depart from Sta.1 on time (7:20 – 8:20)

Contents

Results of Applications

We have applied this procedure when we revised timetable in March 2018.

We confirmed rapid trains run very smoothly. They rarely stop between stations.

Our proposed procedure was very successful!

Conclusions

- A new approach to make a **robust** timetable for dense traffic line.
  - Not only departure and arrival times but we specify **running speed** of trains in a timetable.
- By this approach,
  - Rapid trains can run at an appropriate speed. All trains are able to run smoothly and keep on time.
  - Energy consumption is reduced
- Applied for the real timetable revision
  - Our approach was very **successful**!

If you are interested,

- Yasufumi Ochiai, Norio Tomii : A novel timetabling procedure which considers running speed of trains and its application to actual cases, to be submitted to RailNorkkoping, June 2019, Norkkoping, Sweden.

Thank you for your attention!

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