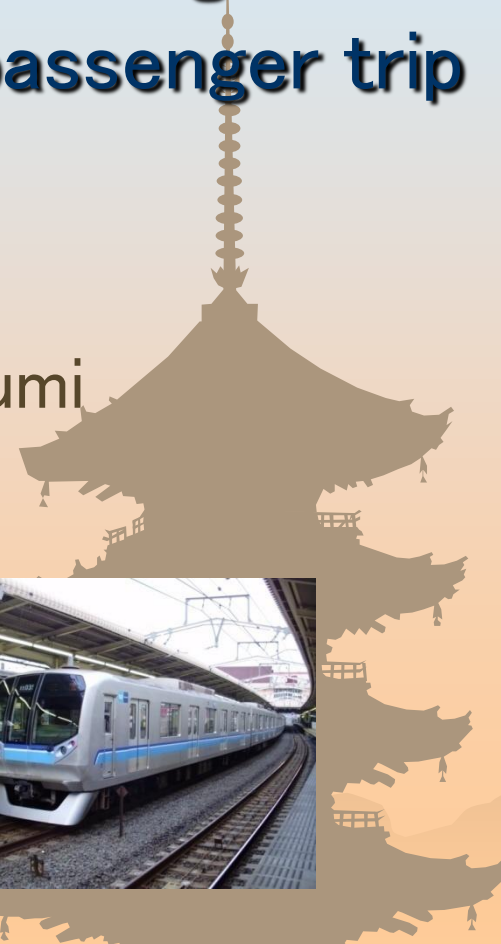
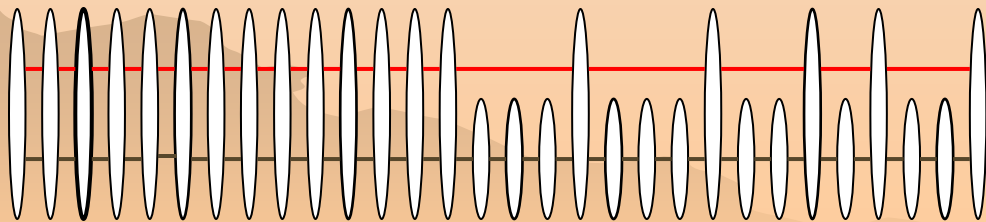


B2 051 Analysis of timetable configurations
of rapid train stopping or overtaking
at stations to shorten the average passenger trip
time

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To shorten the average trip time by...

Hardware approach : improvement velocity

- Improving driving performance, reconstructing signaling system and tracks
- With works, expensive

Software approach : adjusting timetable

- Shortening the waiting time at transfers and operation intervals
- Inexpensive – this study

Rapid train operation : fast and slow trains connection

Needs to adjust rapid train stopping (and overtaking) stations

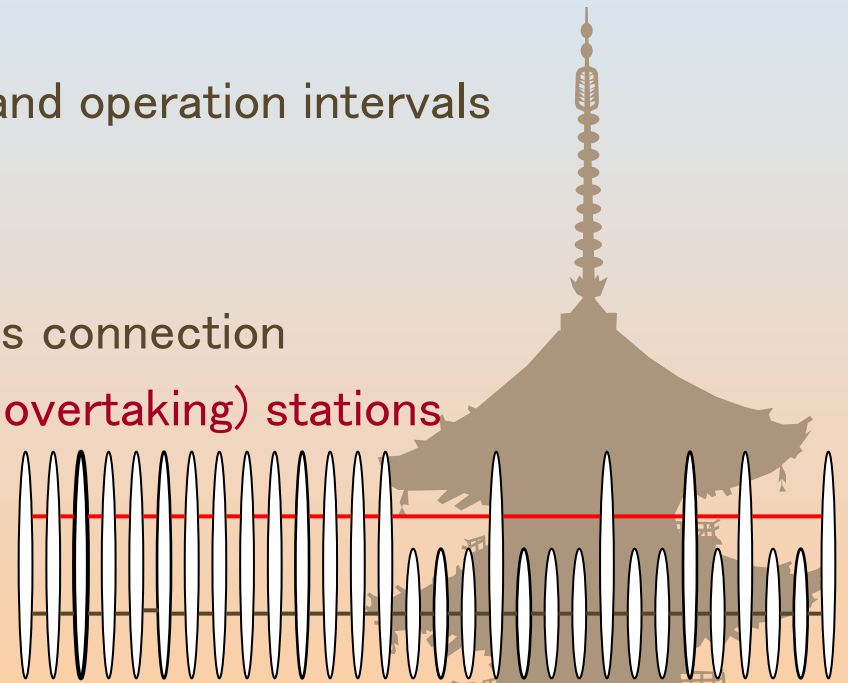
- Improving rapidity and convenience

Stopping stations : Arrangement

Overtaking stations : considering existing infrastructures

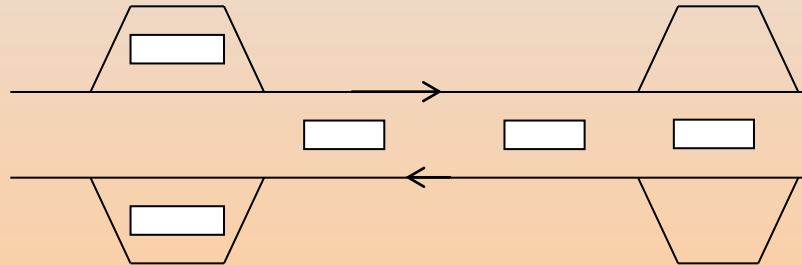
- Generation train diagrams which possible to operate

Combination the stations which shortening average passenger trip time



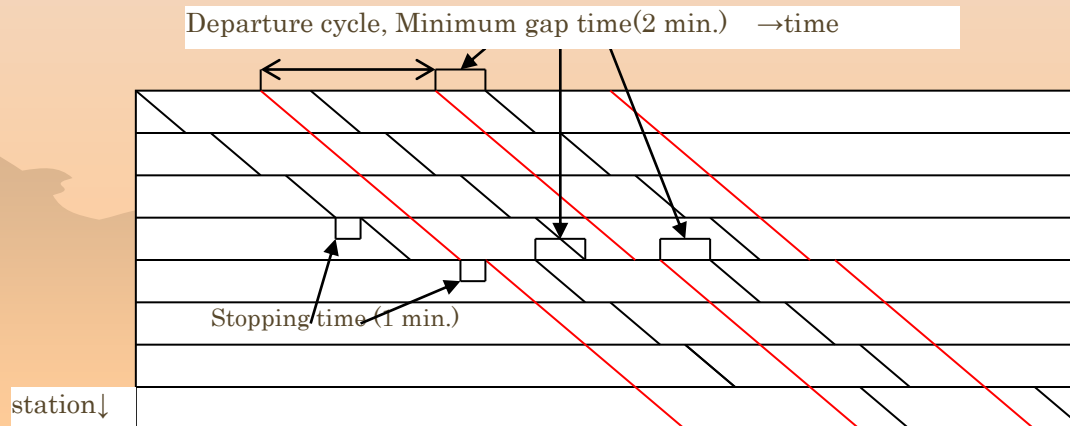
Assumptions for rapid trains operation(1)

- The kinds of trains under consideration are rapid and local trains only.
- The stations where rapid trains stop or overtake the local ones are fixed.
- The train timetable repeats the same pattern every departure cycle.
- The line under consideration has a double track, and rapid trains can overtake the local train at the station only.
- All trains reach the terminal station. No train turns along the way.
- A local train is overtaken a rapid train once only.



Assumptions for rapid trains operation(2)

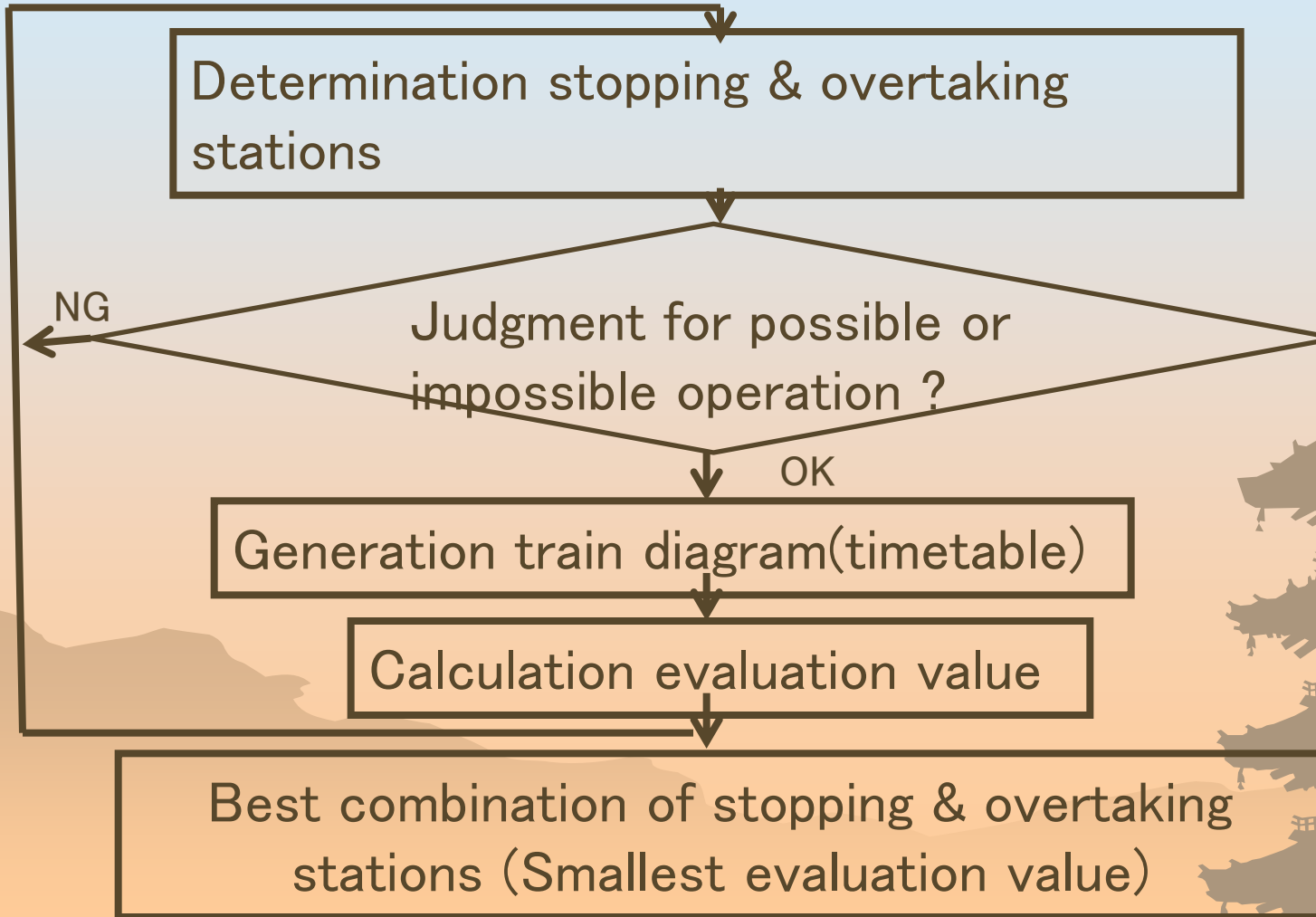
- ❁ The minimum headway time on the diagram is 2 min., and the trains' dwell time is greater than, or equal to 1 min..
- ❁ Rapid trains can shorten dwell time at the stations only, but **cannot shorten running time between stations.**
- ❁ No special fare is required to be paid by passengers, In other words, there is no trade-off between cost and time.
- ❁ All passengers reach their destination by moving only one way.
- ❁ **All passengers who can shorten their trip time by changing trains on the same line do so.**
- ❁ Delay by congestion is not considered.
- ❁ All trains have the same driving performance.



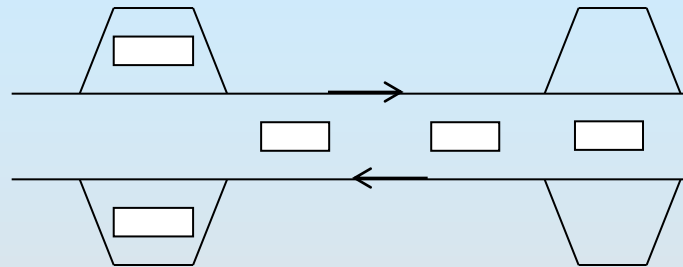
Procedure of determination stopping & overtaking stations

Rapid train stopping stations : 1 0 0 0 0 1 0 0 0 1 1 0 0 1 (1:stopping)

Overtaking stations : 1 0 0 0 1 0 0 0 0 1 0 0 0 1 (1: overtaking)

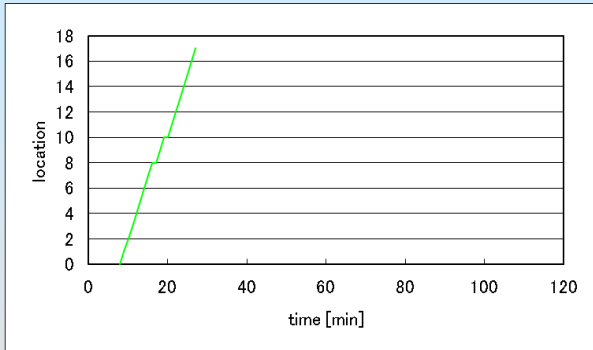


Judgment for possible or impossible operation ?

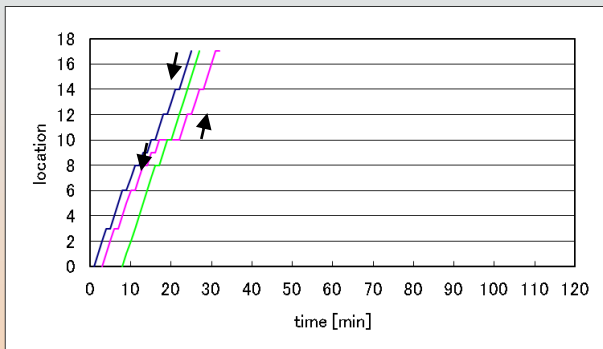


- ❁ For the operation, we need to consider existing infrastructures.
- ❁ Judgement possible or impossible operations by the following assumption – **Minimum headway time on the diagram is 2 min..**
- ❁ When a **rapid train stops at an overtaking station, more than three passing stations** are needed between overtaking stations.
- ❁ When a **rapid train passes an overtaking station, more than two stations** are needed between overtaking stations.

Generating train diagram by stopping and overtaking stations

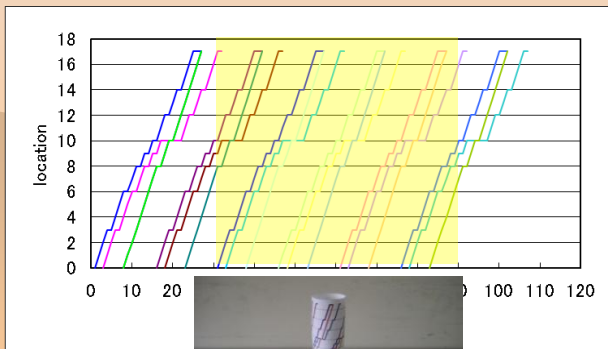


(1) drawing rapid train diagram by its stopping stations



(2) Local train diagram is drawn from overtaken station, to both (up and down) direction.

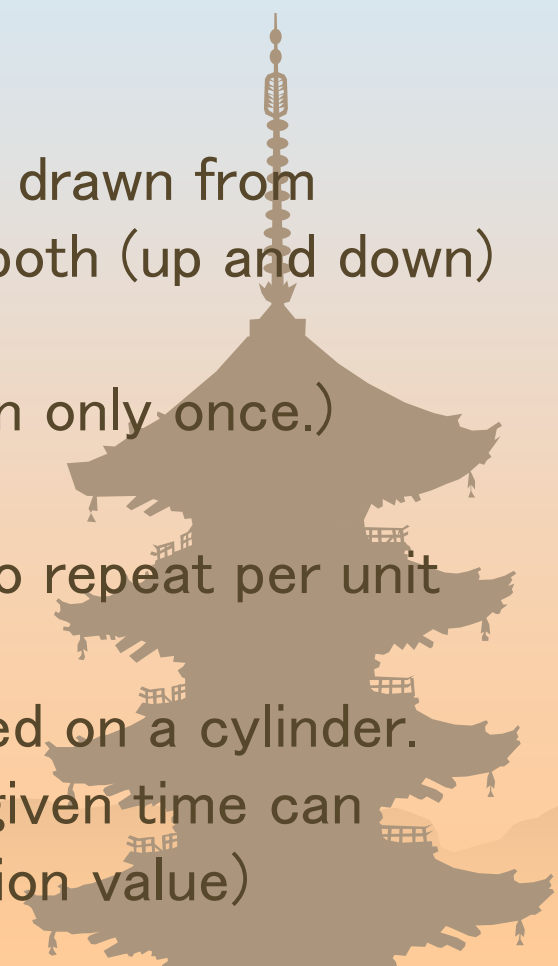
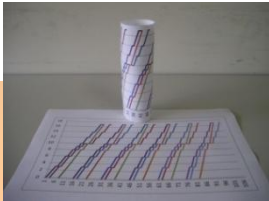
(A local train is overtaken only once.)



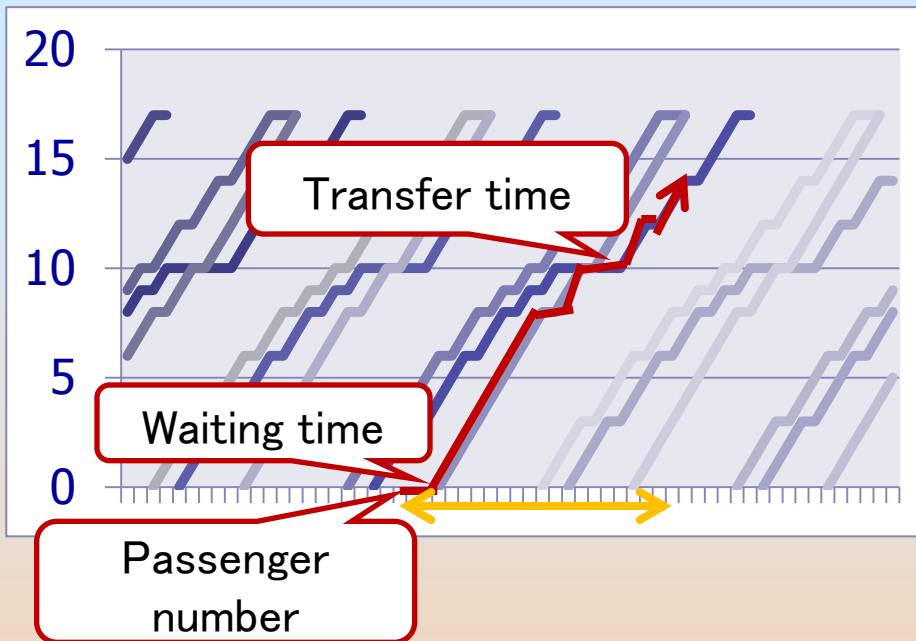
(3) The diagram is set to repeat per unit time (of 60 min.)

The diagram is expressed on a cylinder.

(All passengers at any given time can calculate the evaluation value)



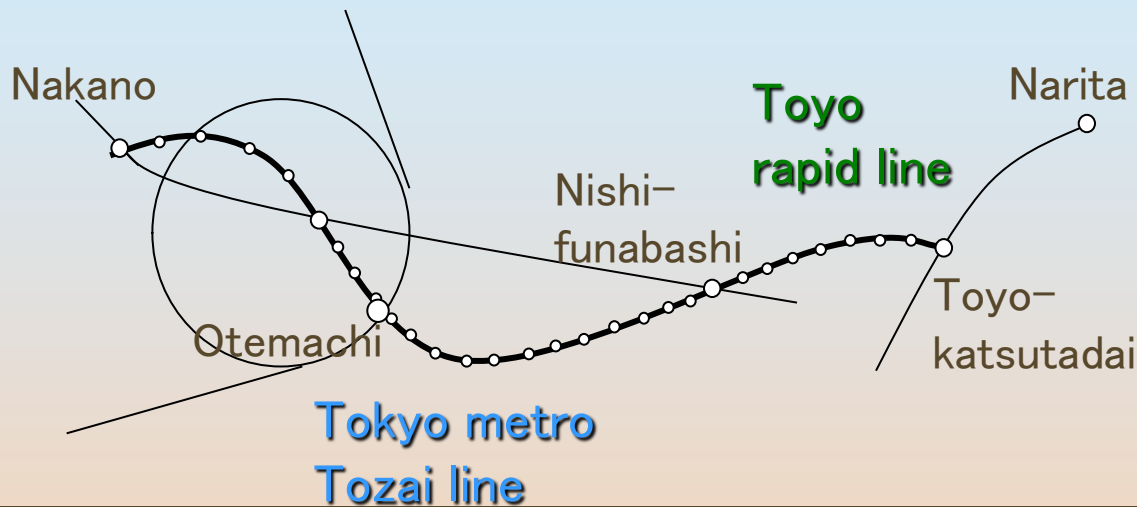
Evaluation value : average passenger trip time (smaller is better)



O \ D	0	1	2	3
0	\			
1		\		
2			\	
3				\

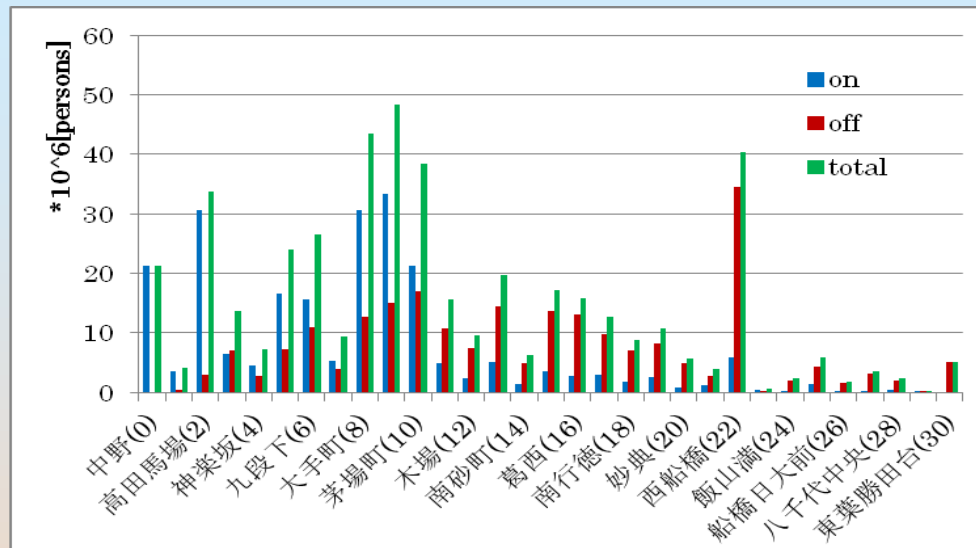
- Average trip time = $\sum_t \sum_i \sum_j OD(i,j,t) * rt(i,j,t) / \sum_t \sum_i \sum_j OD(i,j,t)$ [min]
- $OD(i,j,t)$: number of passengers from station No.i to No.j at time t
- $rt(i,j,t)$: required time to move from station No.i to No.j at time t.
- Passengers by OD come to station No.i, and their destination is No.j.
- Path and required time are searched on train diagram graph
- (This moving time **includes waiting time.**)

Line under consideration (Tokyo metro Tozai line – Toyo rapid line)

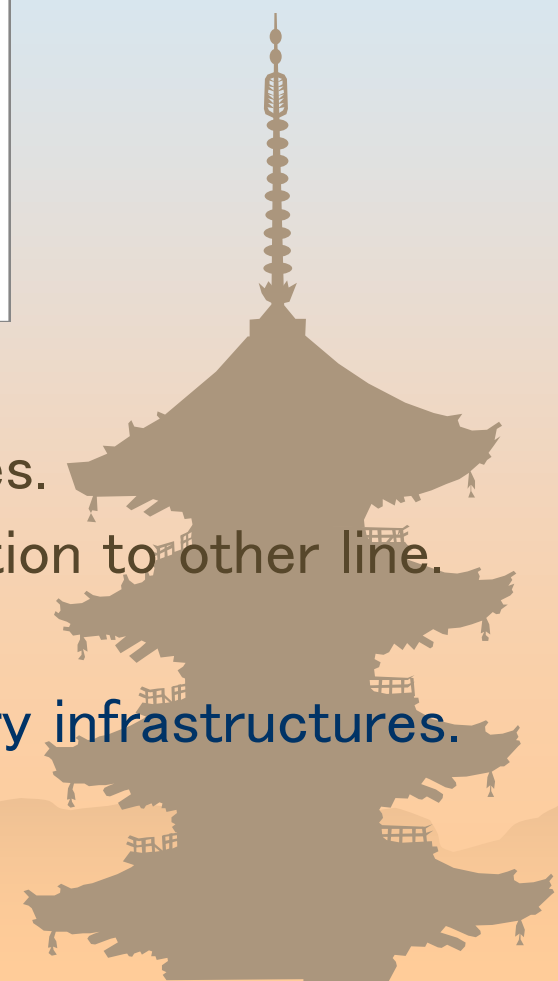


Total length	47 [km]
Station number	31 [stations]
Running time (local train)	73 [min]
Dwell time (local train)	29 [min]
Overtaking infrastructures number	5 stations (no. 16, 20, 21, 22, 27)
Number of trains (daytime)	12 per an hour

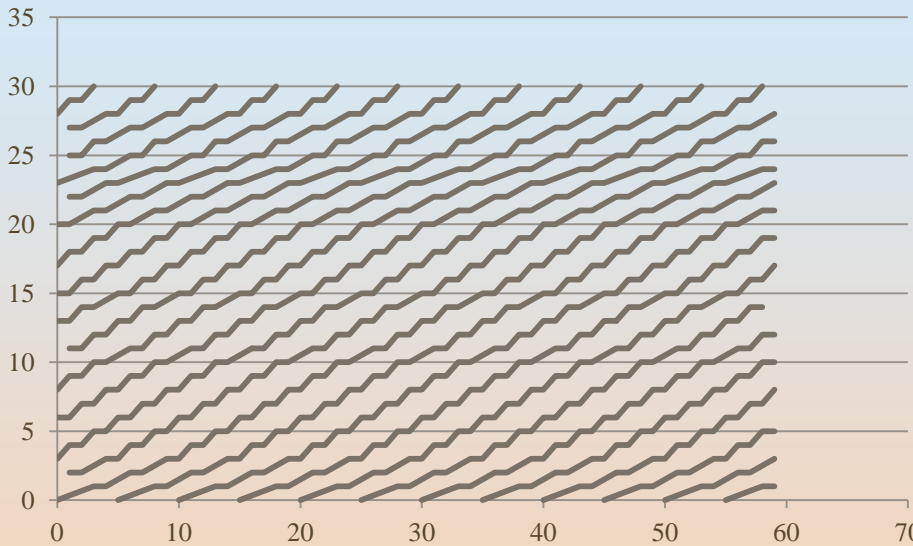
Passengers number at each station (one year)



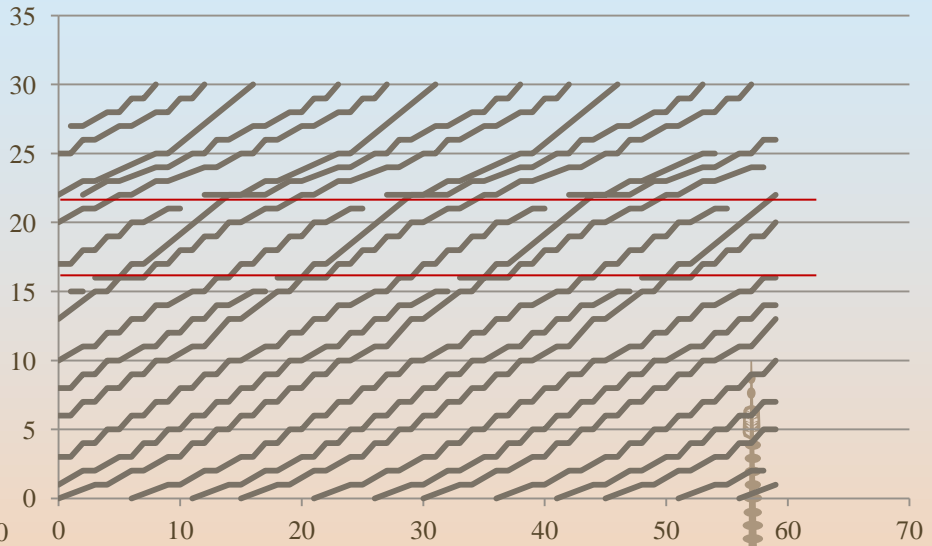
- Station No.8, 9, 10 have a lot of passengers.
- From No.11 and No.21, the number decreases.
- Station No.22 is a border and a transfer station to other line.
- All trains stop border station (No.22).
- Basic overtaking stations have the necessary infrastructures.
- All trains run through onto both lines.



Examples diagram



Local only



Arranged (rough)
(overtaken 16 & 22)

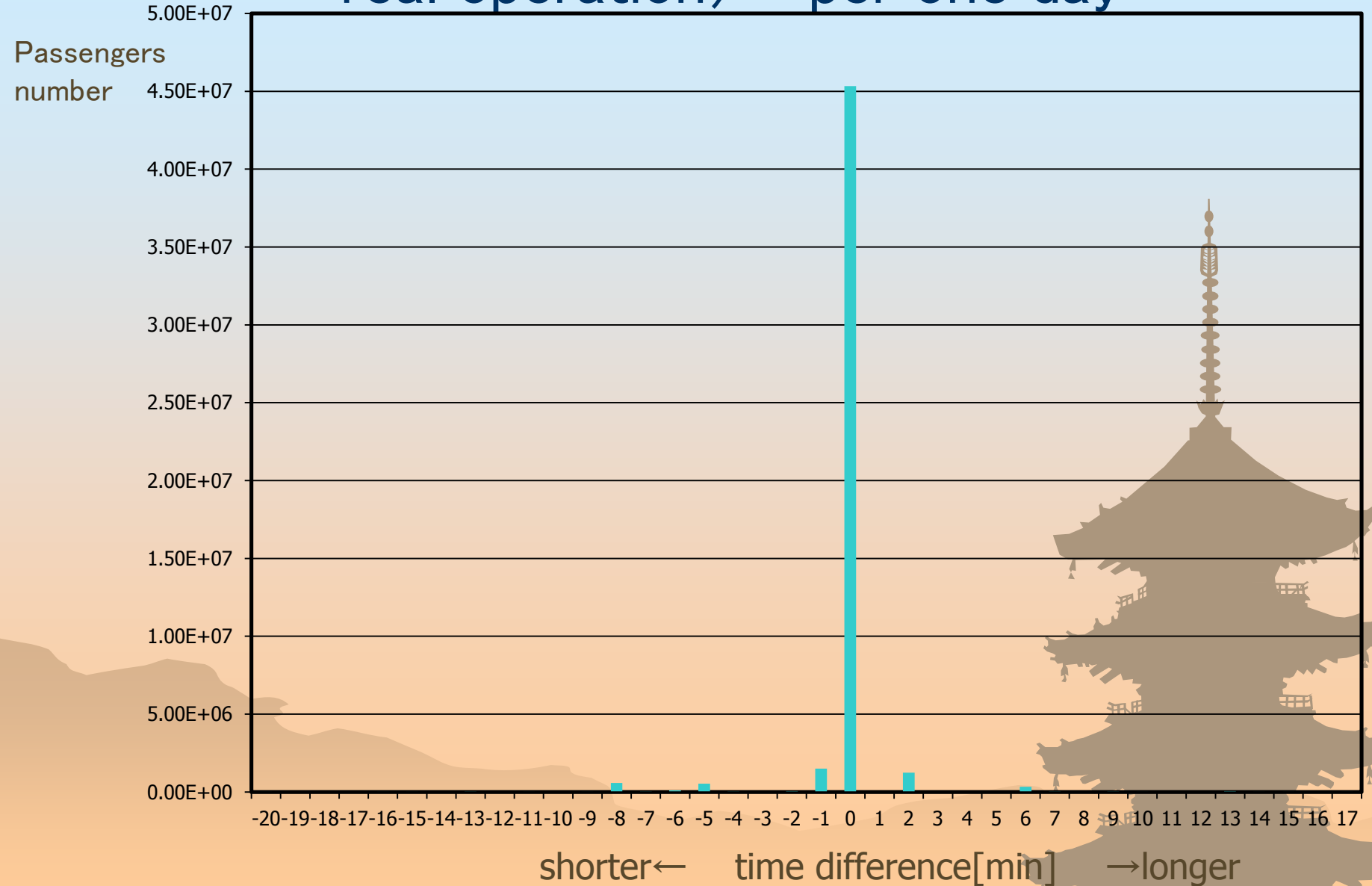


Results and Discussion (all trains stop border station 22)

Overtaking station	Rapid train stopping stations	Average trip time[min]
	Local only	18.77
Real(16,22)	0 1 2 3 4 5 6 7 8 9 10 11 12 13 17 22 23 24 25 26 27 28 29 30	20.53
16	0 1 2 3 4 5 6 7 8 9 10 13 15 17 19 20 21 22 23 24 25 26 27 28 30	20.32
22	0 1 2 3 4 5 6 8 9 10 11 13 15 16 17 18 19 20 22 24 25 26 27 28 30	20.22
27	0 1 2 3 4 5 6 8 9 10 11 13 15 16 17 18 19 20 22 23 24 25 26 27 30	20.27
16 22	0 1 2 3 4 5 6 7 8 9 10 11 13 15 17 22 23 25 30	20.40
16 27	0 1 2 3 4 5 6 8 9 10 13 15 17 19 22 23 25 30	20.26
22 27	0 1 2 3 4 5 6 8 9 10 11 13 15 17 18 19 20 22 30	20.43
16 22 27	0 1 2 3 4 5 6 8 9 10 13 15 17 22 30	20.39

- Only local train operation is very rational operation.
- St. No.8, 9, 10 which have many passengers are adopted for the combination. The results depend on the OD feature. But stopping stations do not based on passenger number.
- If the case of same overtaking stations, determined combination has smaller evaluation value.
- The evaluation values are not so difference.
- More overtaking station number gives few stopping station number, also fewer overtaking stations number gives many stopping station number.
- Shortening trip time is brought by only shortening dwell times.

Δ Shortening effect (overtaking at 16 & 22 st. and real operation) – per one day



Conclusion

- ❁ In order to shorten passenger trip time
- ❁ Adjusting rapid train stopping and overtaking stations
- ❁ Judgment for possible or impossible to express train diagram
- ❁ Evaluation value is an average passengers trip time.

- ❁ The results depend on the OD feature, but not based on passengers number.
- ❁ The evaluation values are not so difference.
- ❁ Shortening trip time is brought by only shortening dwell times, fewer stopping stations supplement loss time by overtaking.
- ❁ Overtaking stations number disturbs passing stations one.

- ❁ Calculation combinations added condition overtaking stations
- ❁ Analysis our results in detail.
- ❁ We continue our search for the best combination !

