Train Trajectory Generation Method to Mitigate Delay Propagation Based on Continuous Train Position Acquisition

—— Stabilization of Train Operation

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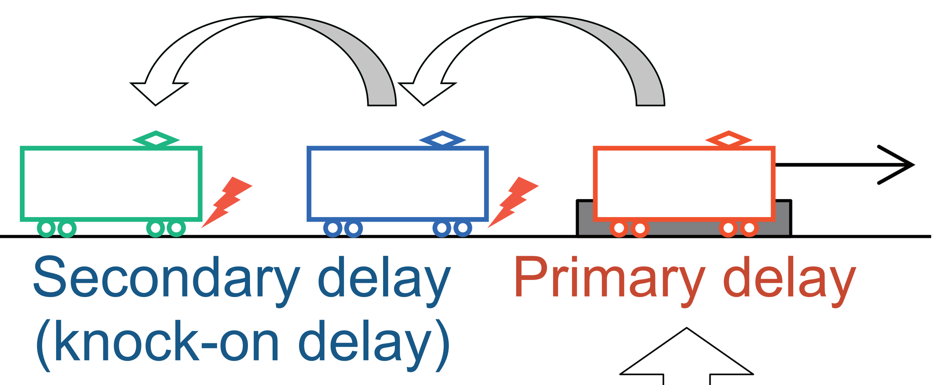
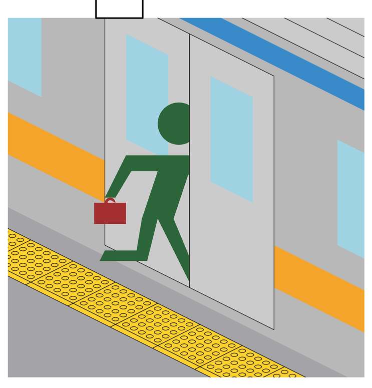
Background and objectives

- Train delays are easily propagated to other trains in urban railways.
- Mitigating delay propagation is important for stable transport.





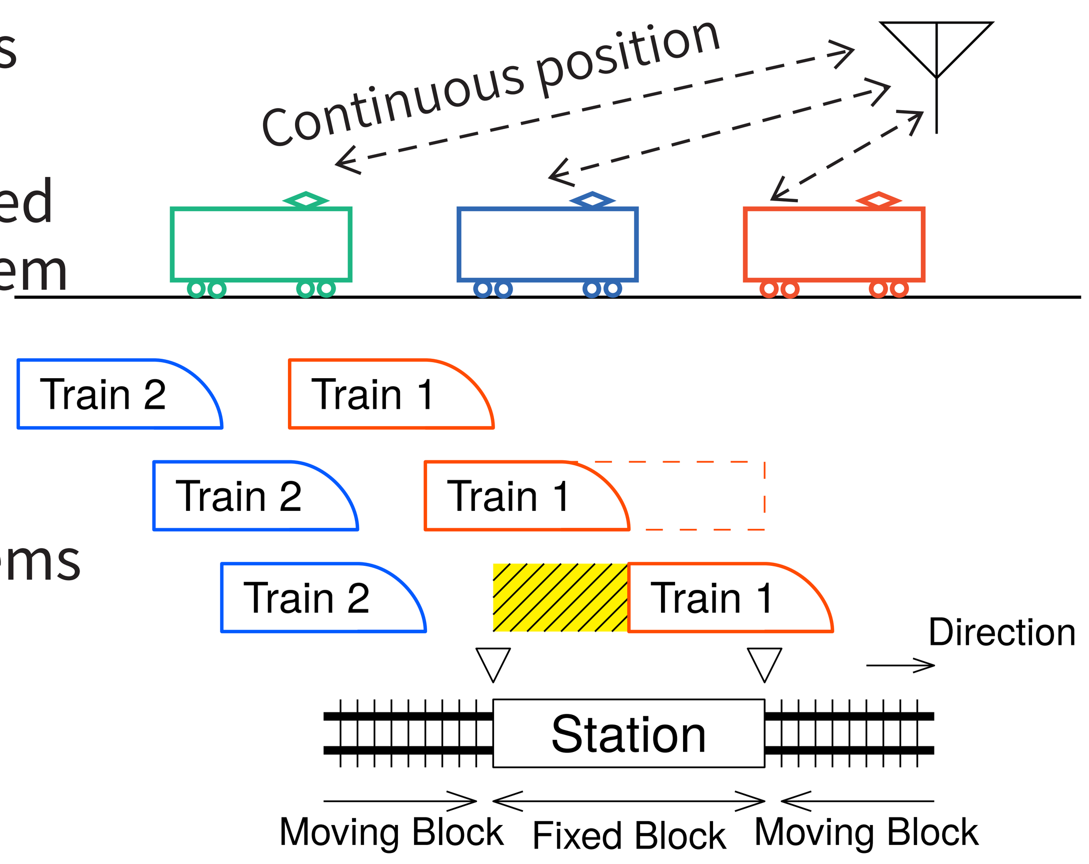
- Previous studies depend on the accuracy of the departure prediction of the preceding train; however, the predictions are difficult.

The objectives of this study

1. To reduce the delay time without departure predictions.
2. To reduce the duration of stopping between the stations with short-time predictions.

Communication-Based Train Control

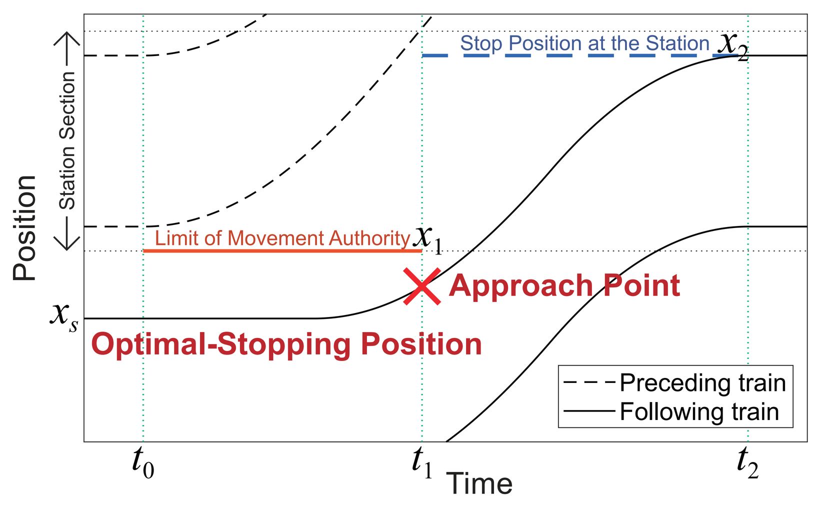
- Railway signaling systems prevent collisions.
- The Communication-Based Train Control (CBTC) system enables continuous train position acquisition.
- Some existing CBTC systems consist of moving block signaling and fixed block signaling.

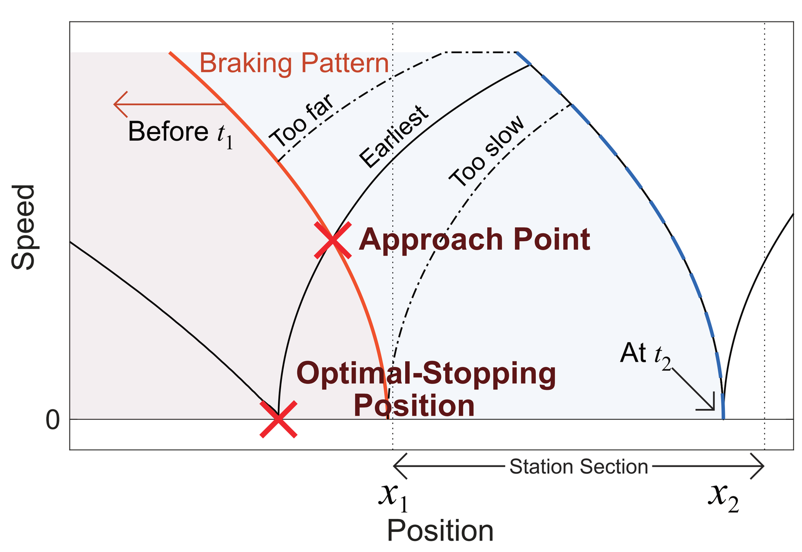


Trajectory generation method

■ Two optimized points

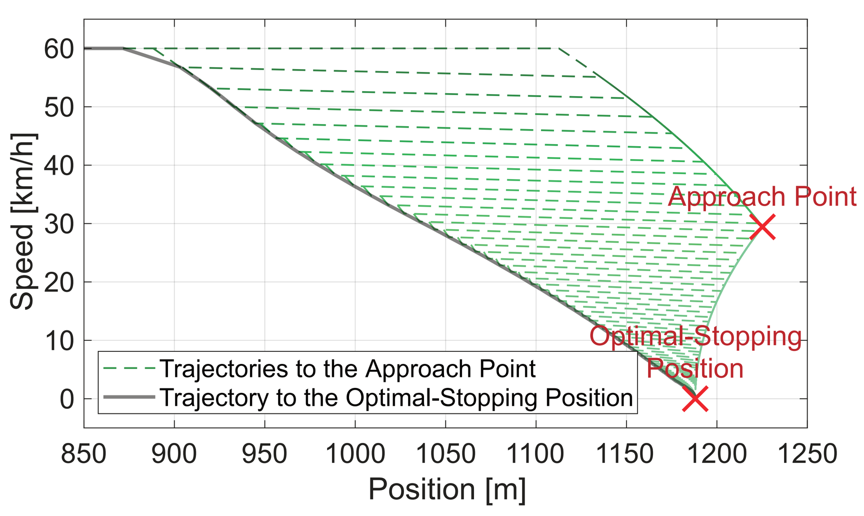
- The approach point is the position and speed pair at the clearing time t_1, which minimizes the departure-arrival interval (Hiraguri et al., 2004).
- The optimal-stopping position minimizes the energy loss due to running resistance during re-acceleration.

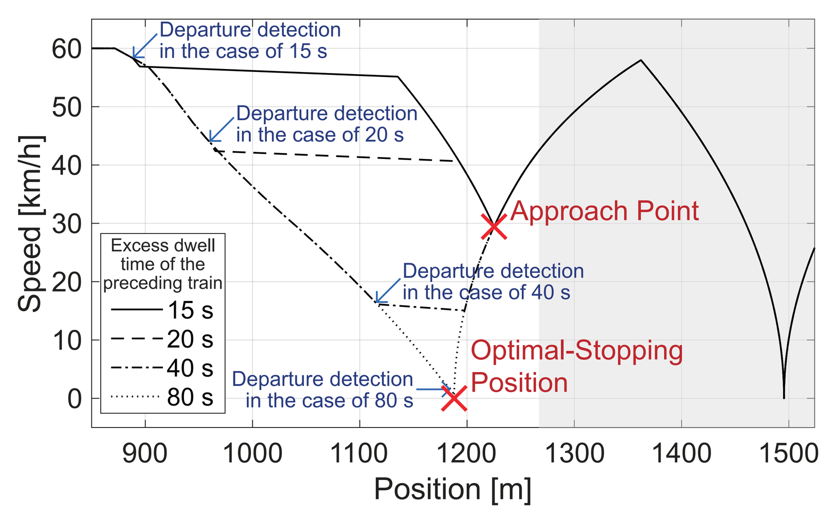




■ Trajectory to these points

- The green dashed lines are the trajectories to the approach point.
- The gray envelope curve is the trajectory to the stopping position.





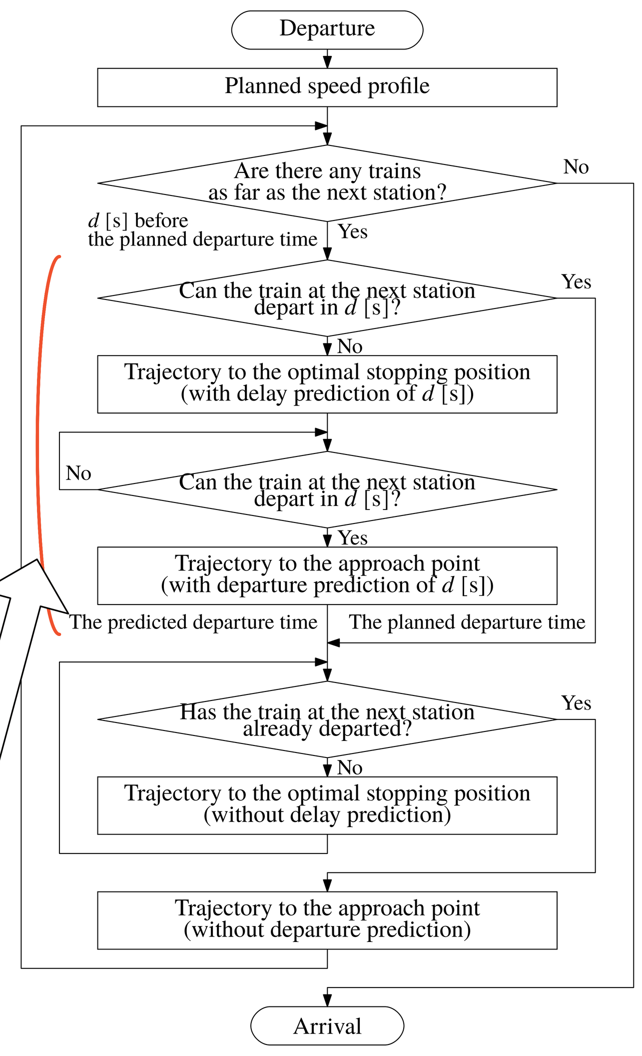
Proposed control method

■ Principle

The following train waits at the optimal position between stations.

Delay prediction ⇧ ⇩ Departure prediction

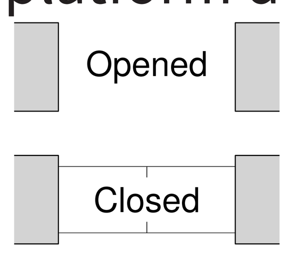
The following train goes to the next station.



■ Prediction method

Sensors
e.g. platform doors

10 seconds later



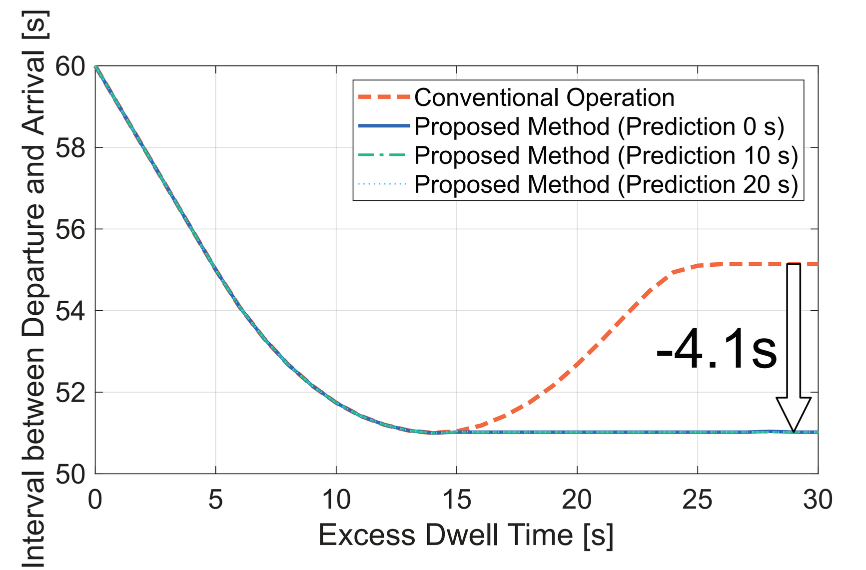
Opened ⇨ Impossible to depart

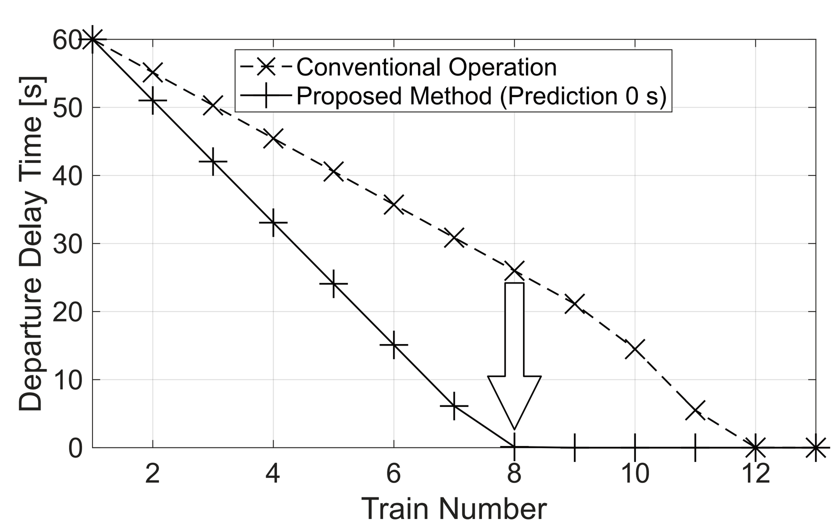
Closed ⇨ Possible

Results

■ Objective 1: the delay time

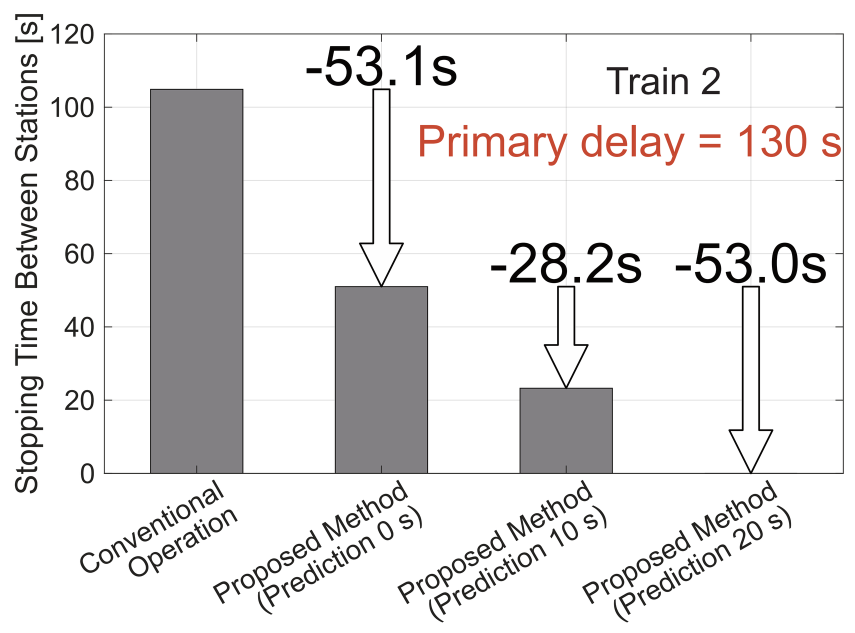
The delay propagation is mitigated as much as possible without departure predictions.

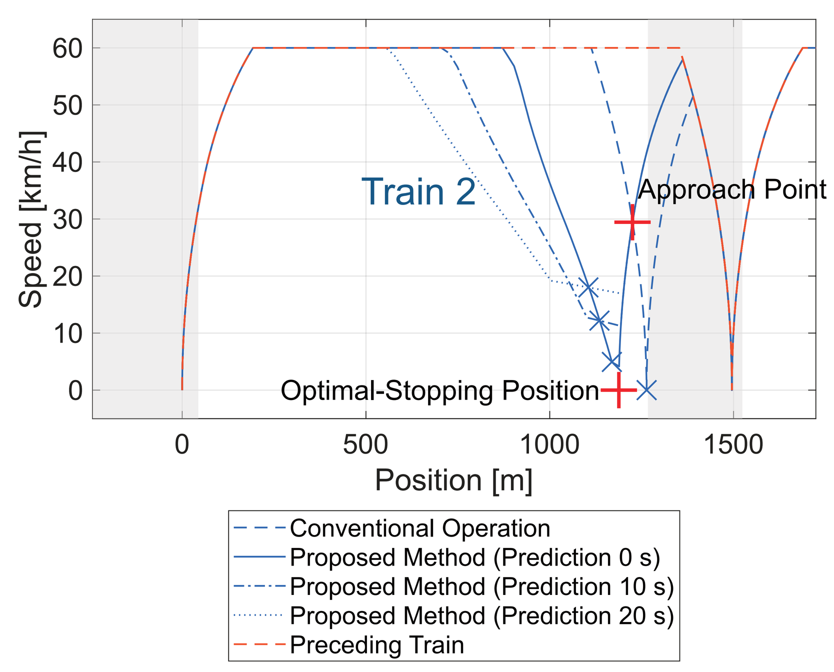


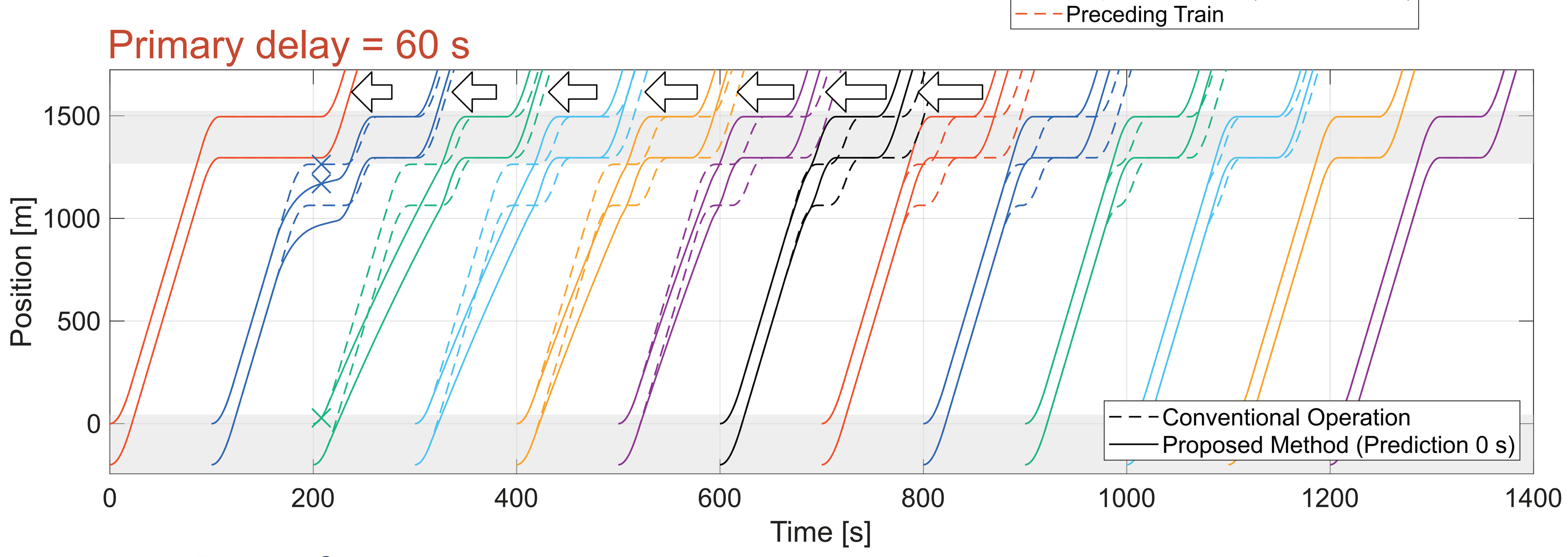


■ Objective 2: the duration of stopping between stations

The proposed method with departure predictions mitigates stopping between stations as well as delay propagation.







Conclusion

- **Usefulness:** The proposed method has a practical advantage in that the driving strategy can be decided without predictions.
- **Future work:** We intend to apply the proposed algorithm to the current CBTC system for on-track tests.

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