Combining speed adjustment and holding control for regularity-based transit operations

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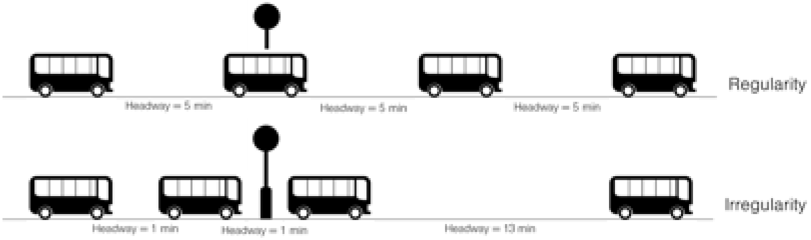
- Control strategy formulation
- Application
- Results and analysis
- Conclusions

Introduction



Bus bunching (Source: Land Transport Guru)

Bus bunching

- Inefficient operation
- Require measures → control strategies

Introduction

Different types of control strategies:

- Holding control
  - Holding/delaying vehicle at control point stop
  - Simple, convenient
  - Increase waiting time onboard → longer generalized travel time
- Speed adjustment
  - Control by speeding up and slowing down the vehicle
  - Holding en-route → cost less
  - Less stable under conditions with more variability
- Combined control strategies
  - Potential improvements

This study:

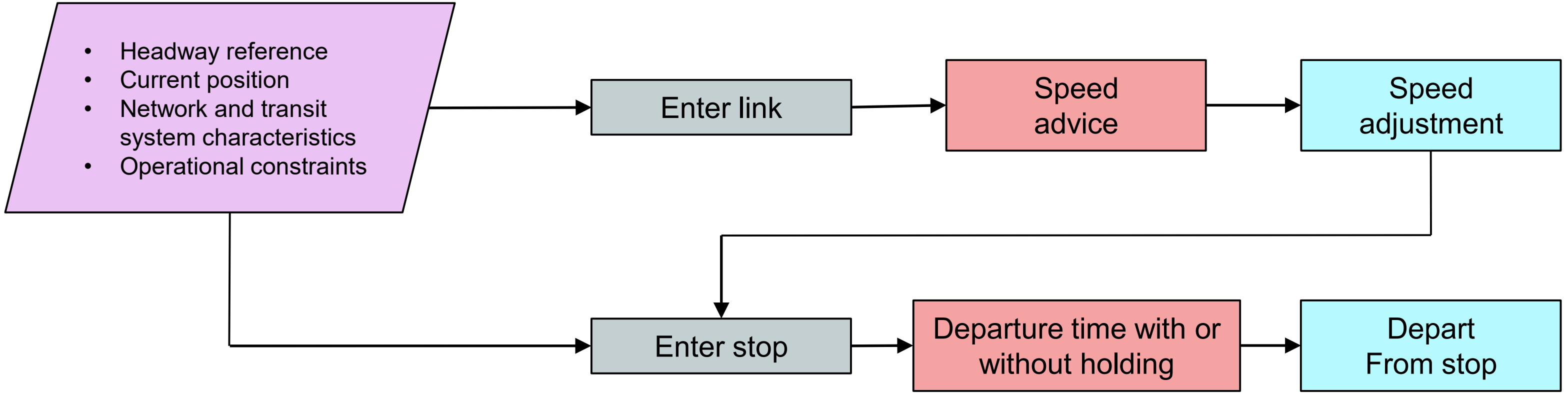
- Combine the potential of holding control and speed adjustment
- Aim at improving regularity and reducing the waiting time onboard
- Impacts?

Control strategy formulation

- Rule-based control strategy

- Assumptions:
  1. Real-time communication between buses (event-based)
  2. Runs on dedicated lane
  3. Neglecting acceleration and deceleration effect
  4. Arrival time prediction based on the scheduled trip time

Control strategy formulation



State 1: Enter link

1. Arrival time prediction
2. Headway checking
3. **Deriving speed advice**

State 2: Enter stop

1. Arrival time prediction
2. Headway/early departure checking
3. **Departure time advice**

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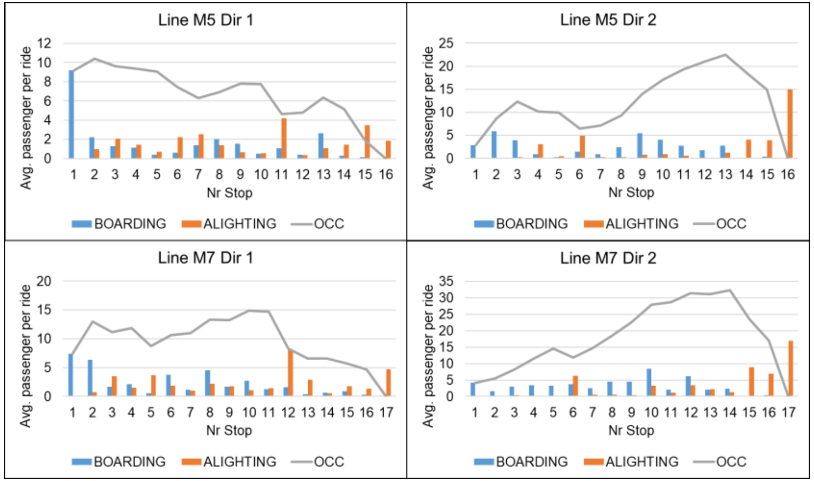
Application

Case study of Almere, the Netherlands

- Run by Keolis Nederland
- High-frequency bus operation (h = 5 min)
- Run on dedicated lanes
- Schedule-based holding control
- Consider 2 lines: M5 (16 Stops) and M7 (17 Stops)
- AVL and APC data April-May 2018



Passenger activity in M5 and M7 (April-May 2019)

Scenario based on trip time scheduling:

- Scenario 1: Normal condition
- Scenario 2: Tighter schedule

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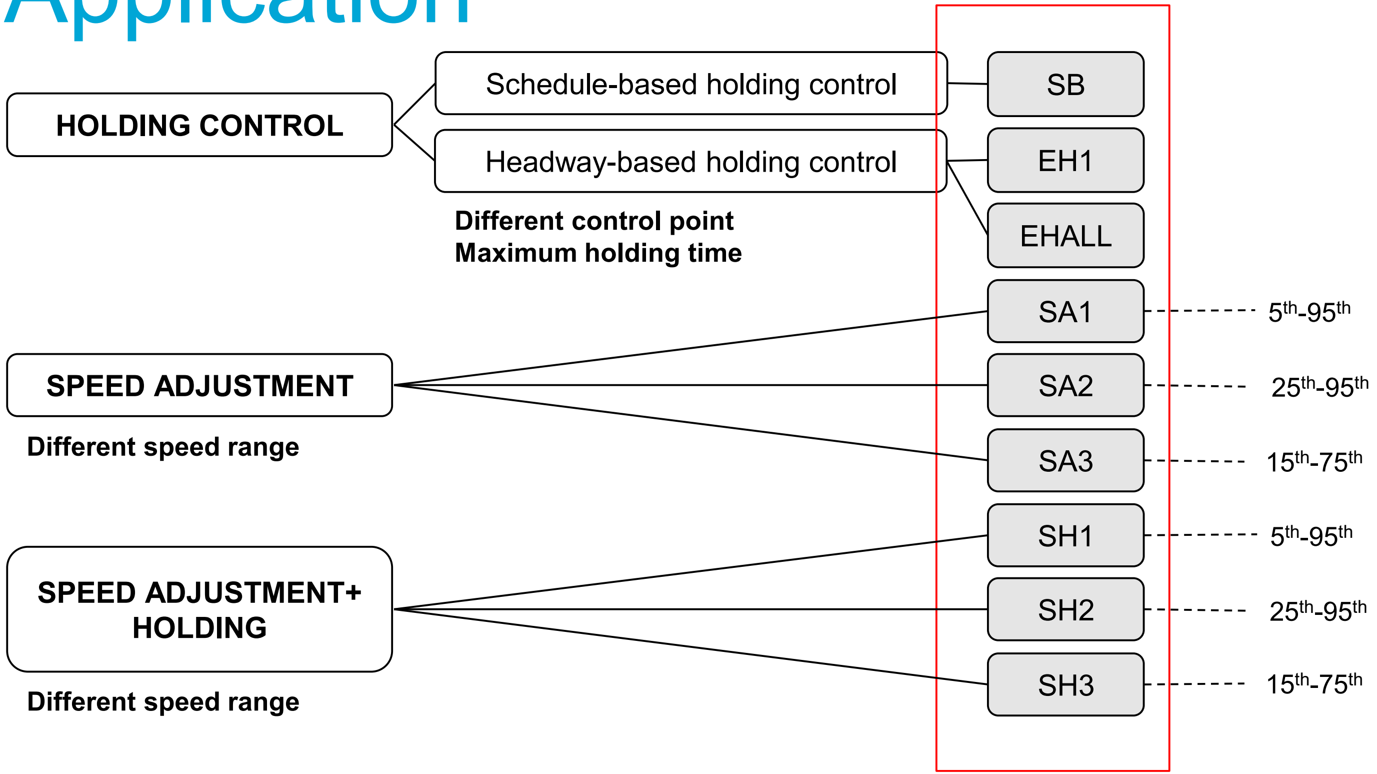
Application



1. Coefficient of Variation (CoV) headway
2. Generalized travel time

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Results and analysis

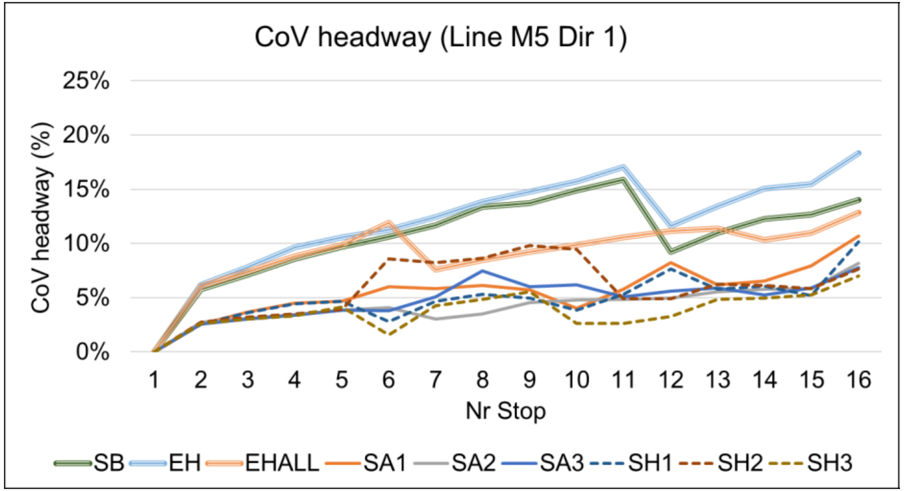
Scenario 1 – CoV headway

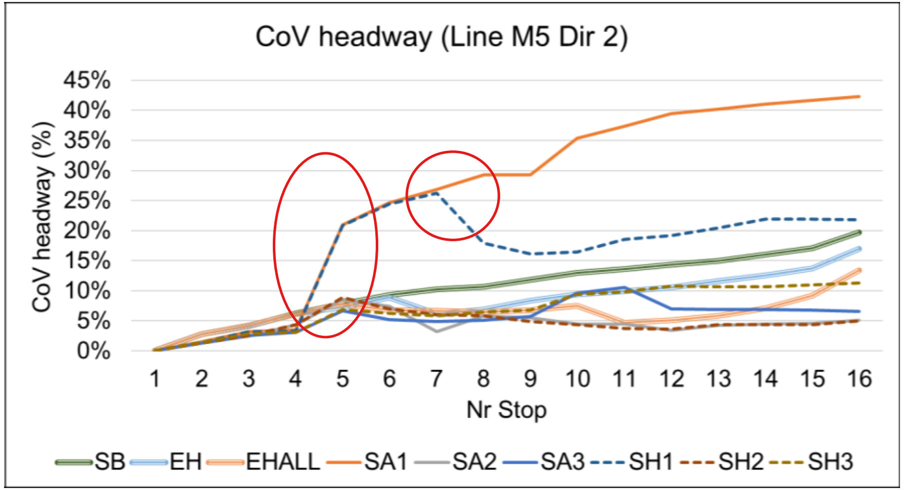
Proposed control strategy (SH):

- **11-63%** regularity improvement compared to holding control
- **0-39%** regularity improvement compared to speed adjustment-only (SA)

Factor affecting the effectiveness of SH:

1. Speed range
   - SH1 in Dir 2
2. Demand pattern
   - SA vs SH





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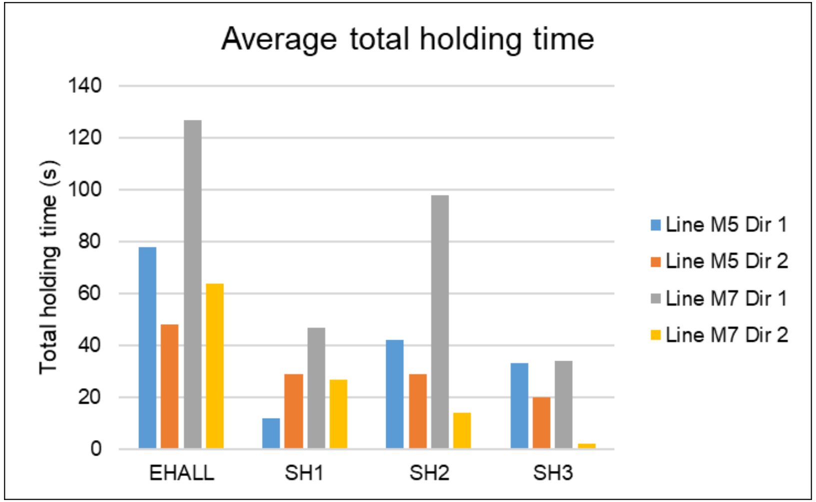
Results and analysis

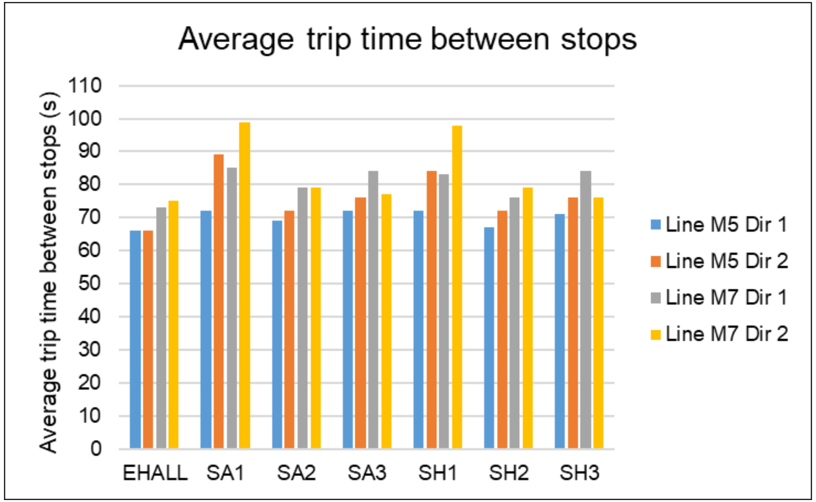
Scenario 1 – Generalized travel time

Generalized travel time (min)								
SB	EH	EHALL	SA1	SA2	SA3	SH1	SH2	SH3
39	40	41	43	40	41	43	41	41

Proposed control strategy (SH):

- **0-4 minutes** longer generalized travel time than holding control
- **23-97%** average total holding time reduction (28–93 s) compared to holding control at all stops (EHALL)
- **1-31%** prolonged trip time (1-23 s longer) between stops compared to holding control





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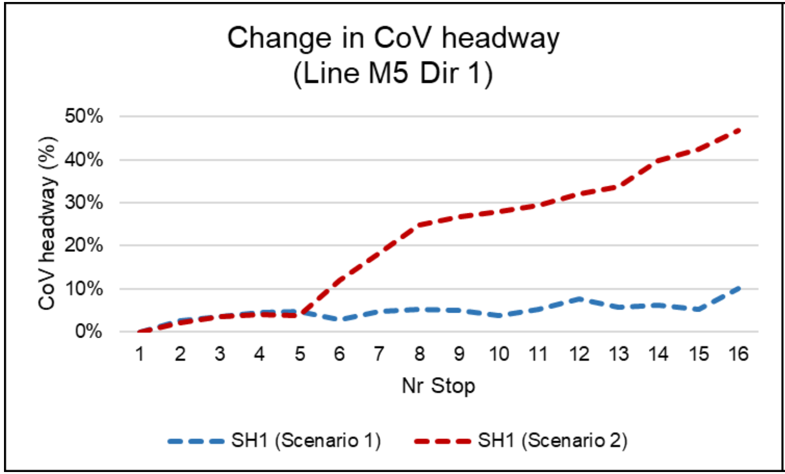
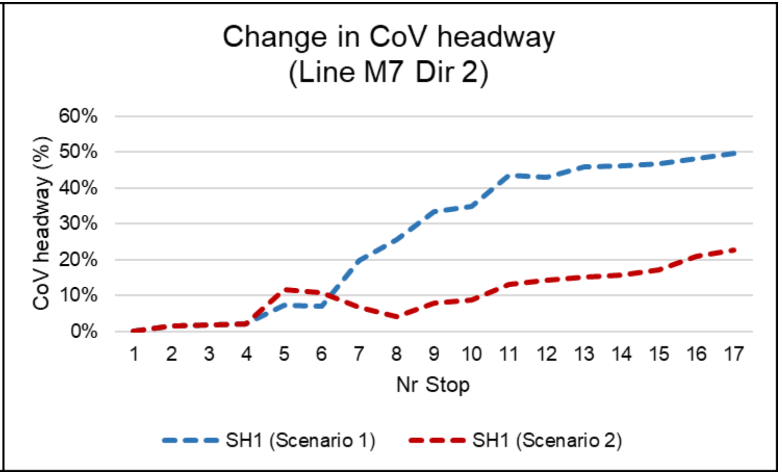
Results and analysis

Scenario 2 – CoV headway and generalized travel time

- Increase in irregularity
- Importance of arrival time prediction
- Example: Line M5 Dir 1 (-305%) and Line M7 Dir 2 (+61%)

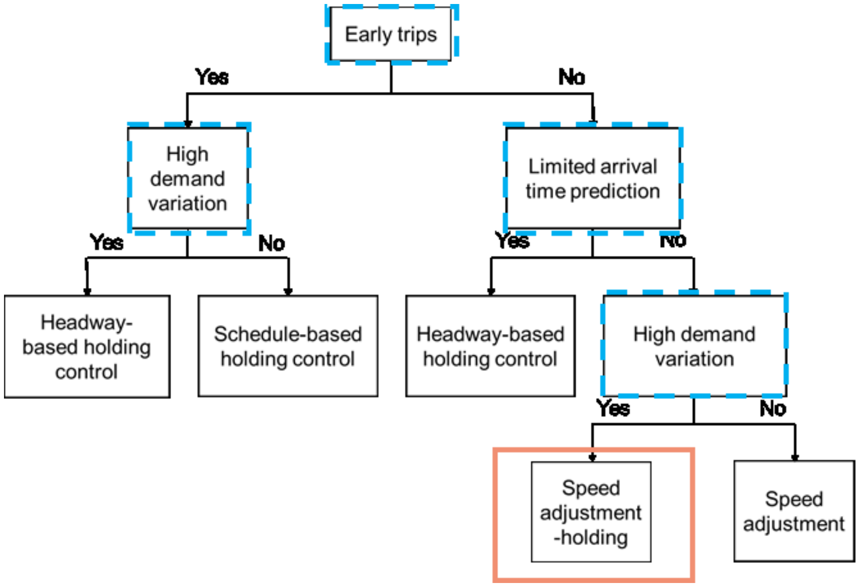




- Longer generalized travel time for all strategies (**7-9%** longer)

Conclusion

- Combining strategies implies combining both the positive and negative attributes of each control
- Line characteristics determine the performance of each strategy



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Thank you!

Question?