# Analysis of Singapore's Bus Bunching Problems Based on Smart Card Data


## Master's Thesis by Jiayao Wang

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### Problem Statement

In public transport, bus bunching refers to a group of two or more buses of the same route arriving at bus stops at the same time. In fact, bus bunching is the consequence of unreliable operation and it is a common phenomenon happening in Singapore. For passengers, bus bunching can increase both the mean and variance of waiting times, traveling time, lead to overcrowding on board and cause dissatisfaction and discomfort to passengers. For transit operators, bus bunching wastes capacity and cause high operation fares.

### Research Objectives

- To evaluate bus service reliability for the entire Singapore's bus system.
- To identify bus routes and bus stops which have recurrent bus bunching problem and visualize them
- To explore the potential causes of bus bunching and quantify their significance in a bus bunching event
- Conduct a case study to probe the bus performance at terminals as well as on route.

### Definition of Bus Bunching

- General case of bus bunching: Buses are regarded as general bus bunching when the headway deviation is larger than half of the departure headway.
- Extreme case of bus bunching: Buses are regarded as extreme bus bunching when the headway is less than 30 seconds.


Fig 1: Image of bus bunching

### Reliability Assessment and Identification of Bus Bunching

- 77.1% of Singapore's bus services were running in a lower and middle class of service quality.
- There are 71 bus routes and 25 bus stops have recurrent bus bunching problem in Singapore, especially route 190, 99 and stop Jurong West Street and Clementi station.
- Areas of Boon Lay, Orchard road and Paya Lebar Road had recurrent bus bunching in AM peak, while areas of Jurong West, Bukit Panjang Road and Woodlands had recurrent bus bunching in PM peak.

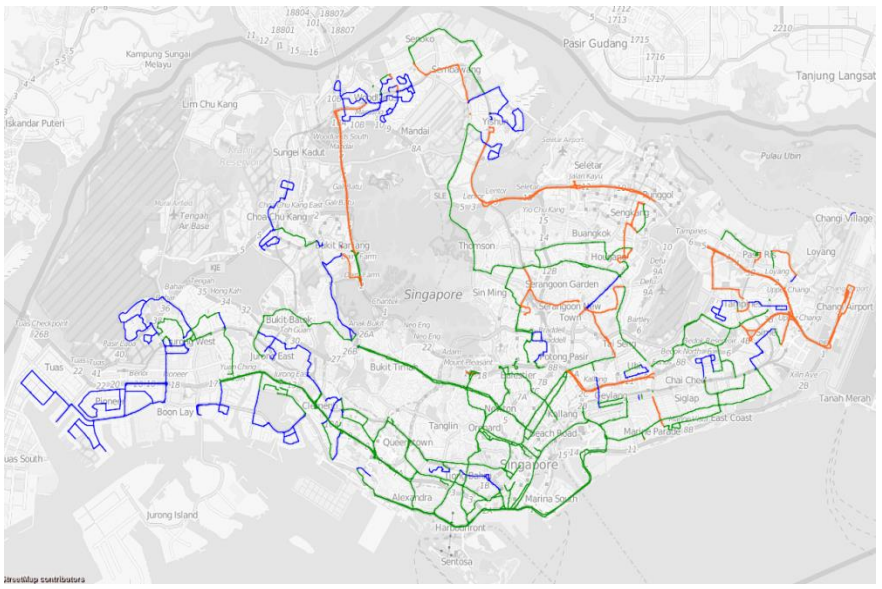


Fig 2: Spatial distribution of 71 problematic routes

Fig 3: Problematic stops at AM peak

Fig 4: Problematic stops at PM peak

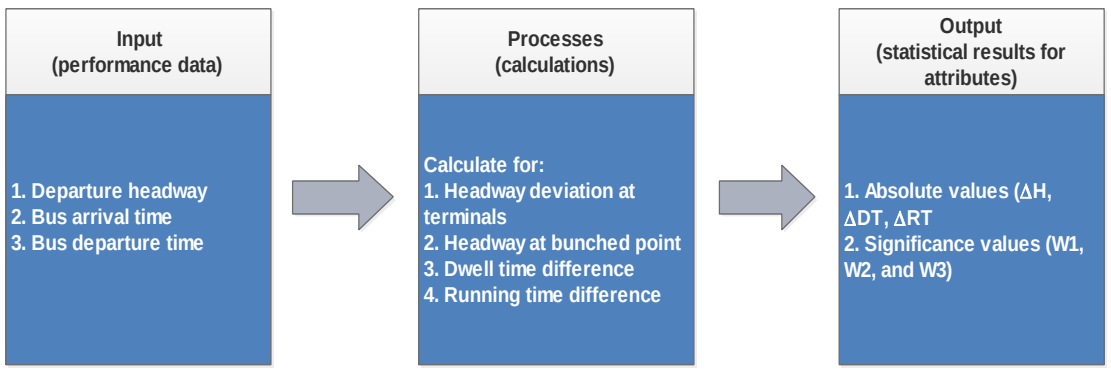


Fig 5: Modeling processes for quantifying the causes of bus bunching

### Modeling of Bus Bunching

For the 71 problematic routes, the significance of variables of causing bus bunching are quantified and the major cause is determined for 5 different time periods.

### Modeling Variables

- Deviations of departure headway at terminals
- Deviation of dwell time
- Deviation of running time

### Modeling Outputs

- Deviations at terminals were the major cause of bus bunching in rush hours
- Varying running time was the major cause of bus bunching in off-peak hours.

### Strategies for Bus Bunching

- Preventive strategies:

Exclusive bus lane; route design; bus bay redesign; supervision at terminals; position track; timetables with uniform headways; driver training; drive incentive sand penalties; supply awareness; orderly queuing system etc.

- Corrective Strategies:

Insert slack time; Holding or expressing; speed adjustment; limit passenger number; signal priority; automatically control scheme etc.

### Case Study: route 183

Performance:

- At terminal: large deviation of dispatch headway occurred during off-peak time.
- At bus stops: the dwell time was varying a lot at Clementi stop at AM peak and PM peak.
- On route: High variability of running time occurred frequently during off-peak time.

Applicable solutions for route 183:

- Strength the supervision management at Jurong East Interchange.
- Holding or expressing to maintain constant headway.
- Control the number of boarding passenger at Clementi stop
- Provide reliable time table for transit users