Methodology for Identification of Bus Bunching using public transport control data

Master‘s Thesis of Leon Weinsziehr

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Objective of the study:

Bus bunching is a phenomenon that occurs in public transport which operates in Right of Way C. Small delays can accumulate, gradually slowing down one particular vehicle. In cases in which such disruptions lead to strongly fluctuating vehicle following times, this results in an uneven load of passengers on the buses and, hence, differing passenger changing times. The result can be the formation of a bunch. It is intended to use publicly available data to make this phenomenon tangible. Three research questions are posed. First, how the phenomenon of bus bunching is described in the literature is dealt with. In close connection with this, what efforts have been made so far to evaluate the phenomenon sharpens the view on the problem. Finally, how bus bunching can be identified and analysed in its spatiotemporal dimensions leads to the data analysis. Table 1 summarizes the steps for the spatiotemporal analysis to be carried out. Table 2 defines the thresholds for the calculated coefficients of variation of headway deviations which determine the proneness to bunching of a route.

Task	Question / Decision	Outcome
1) Determination of Study Scope	What are the objectives of the project’s research?	Research focus
2) Data Acquisition	How can the available data basis be evaluated in terms of the project’s feasibility?	Level of detail of data basis and its feasibility for intended analysis
3) Evaluation Framework	Which KPIs can be measured with the data basis?	Choice of KPIs
4) Choice of Method	Which solution approach from Literature appears to be suitable?	Choice of Solution Approach (Algorithm) to capture chosen KPIs
5) Data Analysis	How can the desired results be obtained from the available data?	Specification of measurement tools and techniques

Tab. 1: Overview about methodological steps

LoS	c_{vh}	Operator Perspective
A	0.00 - 0.21	Service like clockwork
B	0.22 - 0.30	Vehicles slightly off headway
C	0.31 - 0.39	Vehicles often off headway
D	0.40 - 0.52	Irregular headway
E	0.53 - 0.74	Frequent bunching
F	≥ 0.75	Most vehicles bunched

Tab. 2: Schedule Adherence Index

Step	Description
1	Data cleaning
2	Data sorting
3	Headway calculation and bus identification
4	Bus bunching identification
5	Bus bunching distribution and further KPI calculation
6	Data aggregation and plotting

Tab. 3: Principal steps of data analysis

State of the art:

Scientific studies have already matured over several years with regard to the modelling of influencing factors. The picture that emerges is that the passenger change for the dwell time and the traffic condition on route for the travel time most strongly affect the probability of bus bunching. Mitigation actions include control strategies as well as infrastructural measures such as the relocation of bus stops behind intersections. Changes to the route so that fewer left turns or intersections have to be passed through have comparable potential for improvement as the implementation of control mechanisms for bus holding or speed adjustments.

Application of Methodology:

Datasets of two Sydney bus lines with different frequencies (Line 304 - 12 min; 333 - 6 min) serve as a basis for the analysis of bus regularity and bunching event occurrences.

Validation of Method:

Intended as a supplementary process to the core methodology, the deduction of a GTFS real time feed provides a validation option. According to the six-step data analysis, a bunching event is detected, which is subsequently confirmed by the overlap of the position data of the involved buses gained from the real-time vehicles’ positions in the records of the trip updates.

Conclusions:

The results demonstrate the vulnerability of schedule adherence indices to the underlying frequency of buses. Hypotheses concerning the increased occurrence of bunching events in peak hours and a reflection of the major commuting direction are confirmed. The automated detection of bunching events from GTFS-R feeds deserves attention in future studies. The systematised reveal of further metrics such as bunching intensity and severity as well as the derivation of threshold values for the prediction of bunching should not be neglected either.

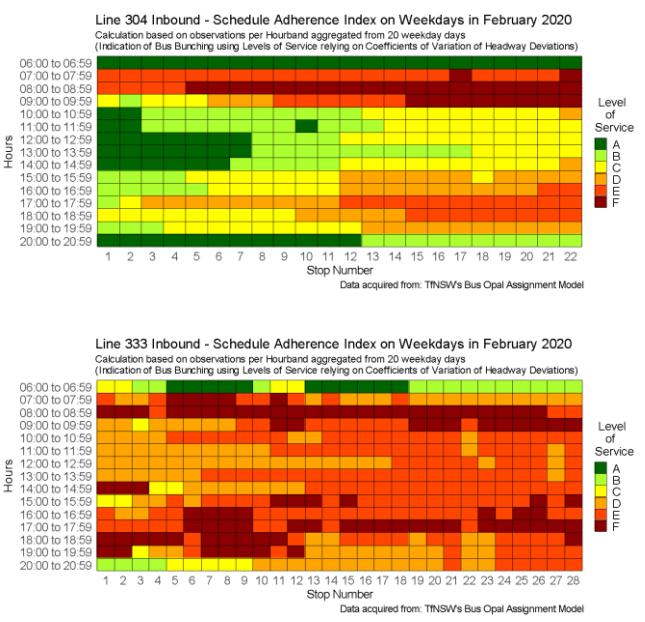

Fig. 1+2: Levels of Service of Line 304 and 333; inbound direction

Fig. 3+4: Investigated bus routes