Bus Bunching Detection by Mining Sequences of Headway Deviations

Luis Moreira-Matias, DEI-FEUP and LIAAD INESC-Porto L.A.
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1. PROBLEM: BUS BUNCHING (BB)

* Urban Bus Networks
* High Frequent Routes
* Traffic Jams, High Demands, Unreliable Schedules

1) A Bus Delay reduces the headway for the next bus;
2) The first bus will have more passengers in the next stop than expected;
3) The next bus will have fewer passengers in that stop than expected;
4) The headway will reduce more and more in a snowball effect;
5) THE TWO BUSES WILL FORM A PLATOON IN A STOP AHEAD!

2. OUR APPROACH: BUNCHING BLACK SPOTS

We identified sequences of bus stops with systematic headway deviation (HD) patterns in trips with BB occurrences: Bunching Black Spots (BBS), i.e., bus stops where a HD will, with a high probability, cause a BB in the following bus stops of the trip.

MAIN STEPS:

1) We calculated Headway series: for each Bus Stop, we calculated the time between every two pairs of Buses;
2) We considered a Bus Bunching occurrence in the travel X (set of headways measured in the bus stops that are part of the travel route) containing every headways xi when there exists at least one headway shorter than 25% of the starting one (f):

\[ E \times 0 < x_i \leq (0.25 \times f) \]

3) We filtered those sequences into an high-pass filter, turning them into Headway Deviation (HD) events (ht is a user-defined threshold for the deviation).

\[ H = \begin{cases} 0 & \text{if } x_i - x_{i-1} < f \times ht \\ 1 & \text{if } x_i - x_{i-1} \geq f \times ht \\ -1 & \text{if } x_i - x_{i-1} \leq f \times ht \end{cases} \]

4) Finally, we mined the HD sequences using Sequence Mining algorithm: the prefixSpan;

3. RESULTS AND CONCLUSIONS

Main Sequences Obtained (length 1 and 2) (potencial BBS identified)

<table>
<thead>
<tr>
<th>Sequences</th>
<th>Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>201_1 (7 to 12h)</td>
<td>S1: GGF=1, CMO=1</td>
</tr>
<tr>
<td>S2: GGF=1</td>
<td>29%</td>
</tr>
<tr>
<td>S3: CMO=1</td>
<td>29%</td>
</tr>
<tr>
<td>S4: AL4=1</td>
<td>43%</td>
</tr>
<tr>
<td>305_1 (7 to 12h)</td>
<td>S1: C24A=1=1</td>
</tr>
<tr>
<td>S2: PKD2=1</td>
<td>42%</td>
</tr>
<tr>
<td>S3: SDBR=1</td>
<td>57%</td>
</tr>
<tr>
<td>305_2 (7 to 12h)</td>
<td>S1: ASP3=1</td>
</tr>
<tr>
<td>201_1 (16h to 21h)</td>
<td>S1: AL4=1</td>
</tr>
<tr>
<td>305_1 (16h to 21h)</td>
<td>S1: SDBR=1</td>
</tr>
<tr>
<td>305_2 (16h to 21h)</td>
<td>S1: ASP3=1</td>
</tr>
</tbody>
</table>

Total Results

Notes:

- These results consider just the partition containing travels with one or more BB occurrence.
- ht = 0.15
- Support=0.4 in the partition bunching=1 to identify a BBS

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Publications: