Simulating Kerb-Lane Traffic Stoppages at Streetcar Stops Without Safety Islands

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Introduction

Dating back to the 19th century, the Toronto Streetcar system operates in constrained environments seen in few other cities around the world. A high proportion of its 83 km of trackage operates on four-lane roads in mixed traffic, and the vast majority of stops lack safety islands. At these stops, boarding and alighting passengers must cross and block the kerb lane, forcing this live lane of traffic to stop. Due to the rarity of this phenomenon, few standard traffic analysis tools that are capable of analysing this behavior accurately have been developed. This paper reviews existing efforts to simulate this behaviour, and proposes a new tool meant to improve accuracy of these simulations. In this paper, the term "blocking streetcar" refers to any streetcar that would cause traffic in the adjacent lanes to stop, either in anticipation of streetcar loading, or during streetcar loading itself, at stops without safety islands.

Review of existing practices

Unlike other software such as Paramics, Vissim does not have a built-in setting known to the author to simulate kerbside blocking streetcars. However, a number of workarounds have been explored:

1) Using Priority Rules: This method adopts a similar approach used by COWI in its 2013 study to model cyclists around bus stops in Copenhagen. A priority marker and stop-line are placed in the streetcar lane and kerb lane, respectively. In deciding whether or not to stop, kerb-lane drivers would thus be able to consider only the position of the streetcar and would be unable to consider its deceleration or loading state. Furthermore, traffic would be unable to consider streetcars stopping at slightly different positions within the stopping zone. This usually occurs when congestion prevents the streetcar from proceeding to its desired position at the front of the stop to load. Under the above conditions, traffic may be stopped unnecessarily even if the doors of stationary streetcars are closed but are still touching the conflict marker. Traffic may also fail to stop at the correct location, or stop entirely, if the conflict marker or the stoplines happen to be in the wrong position.
2) Microsimulating boarding/alighting passengers as pedestrians: Pedestrians crossing the kerb lane can either force traffic to stop by constructing a pedestrian area over the kerb lane. A conflict area can then be defined that gives these passengers the right-of-way over kerb-lane traffic. Alternatively, a pedestrian-actuated detector can be placed on this link that changes a signal head indication to red. However, this method fails at forcing drivers to begin stopping in anticipation of a blocking streetcar. Traffic would tend to stop abruptly at the "last-second", well after the streetcar comes to a stop and only after the streetcar doors open. At stops with lower pedestrian activity, cars would often sneak past open doors between passenger crossings. Furthermore, this method is available only to those with an additional Viswalk license.

The shortcomings of existing methods provided motivation to develop a script that would:

- allow drivers to observe the exact state, speed and deceleration of the adjacent streetcar, in anticipation of it stopping;
- allow drivers to stop at the correct position with respect to a blocking streetcar; and
- be readily available for Vissim users with a standard license.

Methodology

The script was written in Python and consists of the following components:

1) A definition of a blocking streetcar;
2) A list of all vehicles that meet the definition of a blocking streetcar, which is updated at every time step; and
3) A method to stop kerb-lane traffic around a blocking streetcar;

Definition of a Blocking Streetcar

The definition of a blocking streetcar includes any streetcar that:

1. Is in any lane except for the kerb lane;
2. Is fully within a stopping zone that lacks a safety island and:
    a. is also decelerating and has a low speed, whose threshold can be arbitrarily set; or
    b. has its doors open (if the PTDwellTm is not "NoneType"); and
3. Did not already serve the stop recently.

Initially, the criteria for a blocking streetcar also included an intention of a streetcar driver to serve the stop, which could be indicated by its Interaction Target Type of "PTStop". This criteria works well only in the absence of congestion, where streetcars are free to stop at their desired default position within the stopping zone, usually at the front end of the stopping zone. However, in the presence of traffic congestion, streetcars are prevented from reaching the front end of the stopping zone but are still able to serve passengers. However, these streetcars would have an Interaction Target Type of "Vehicle", even after the streetcar opens its doors. Therefore, relying on the Interaction Target Type to be "PTStop" can fail entirely at stopping traffic. In reality, drivers are able to directly observe only the speed, deceleration and next stop of the streetcar, but cannot directly observe the thoughts of the streetcar operator herself.

A list of all vehicles and their attributes that meet the above definition is generated and updated at every time step. For each streetcar in this list, kerb-lane traffic is stopped by means explained in the following section.

Stopping Kerb-Lane Traffic

For every blocking streetcar in the list of updated vehicles, a stationary dummy "blocker" vehicle is placed in all adjacent lanes of the streetcar, at the same position as the blocking streetcar, only if there aren't any blocker vehicles already. Blocker vehicles of different lengths would have to be defined for each streetcar length. At every time step, the blocker vehicles are removed if there is no longer a blocking streetcar in the adjacent lanes. Due to the definition of a blocking streetcar, blocker vehicles are placed even before the streetcar comes to a complete stop, simulating the kerb-lane drivers' anticipation of blocking streetcars. The expected position of a blocking streetcar once it comes to a full stop can also be estimated in advance using the streetcar's speed and deceleration.

The script can be modified to adjust the aggressiveness or prudence of kerb-lane traffic. For example, the speed of a blocking streetcar can be decreased to cause kerb-lane drivers to begin stopping later, simulating more aggressive behaviour.

Conclusion

The result of this study is a tool that can simulate traffic around blocking streetcars more accurately than previous methods. The tool can be adapted to regions with different driver behaviours.