The Cell Transmission Model: A Better First-in, First-out Traffic Flow Approximation

G. Peque
Center for Spatial Information Science, The University of Tokyo
Contact: <gpequejr@csis.u-tokyo.ac.jp> Web: <http://www.csis.u-tokyo.ac.jp/>

(1) Introduction: The Cell Transmission Model (CTM) is one of the most widely used continuous-traffic dynamic network loading (DNL) models. It provides a reasonable representation of physical queues and their spillback through merge and diverge nodes, in conjunction with computational tractability. The CTM assumes a first-in, first-out (FIFO) traffic flow rule which rely on FIFO approximation. Recently, the first method for computing the CTM solution that satisfies the FIFO condition was proposed. However, the method has an exponential computational and spatial complexity and thus, can only be used to benchmark the CTM solution. Interestingly, this ability to benchmark the solution allowed us to develop a better FIFO approximation method for the CTM.

(2) Method: The dynamic nature of traffic makes difficult to analyze and numerous models have been proposed for this purpose. Among the fundamental components of these modeling efforts is dynamic network loading (DNL). In DNL, all choices of travelers are assumed to be known, including origins, destinations, departure times, modes and routes. There are many DNL models and one way to categorize them is by the representation of traffic, discrete or continuous. While FIFO is trivial for the former, it is not the case for latter. Recently, a method was proposed to compute exact FIFO solutions for the CTM which is one of the most common continuous-traffic DNL model by splitting traffic according to priority. Splitting traffic usually occurs at merge nodes where the traffics' order of entry needs to be maintained (not done in the CTM). However, this has an exponential computational and spatial complexity with respect to time. In this paper, a method to reduce the exponential complexities are proposed.

(3) Result: Figure 1 shows the traffic network used for the simulation. It has 4 routes that merge on nodes 1 and 6. Traffic passing through merge nodes needs to be split to maintain its FIFO order. The simulation starts with a demand equal to the minimum link capacity in the network. On the 8th iteration, a slight increase in the demand is added on origin nodes 9 and 10 which is reverted at iteration 9. This slight increase in demand in a single iteration causes traffic splitting to grow exponentially with respect to time (Figure 2). Therefore, a method to merge split traffic to avoid this problem is developed. The method focuses on the selection of split traffic to merge using a merging criterion.

(4) Reference:

Daganzo, C.F., (1994). The cell transmission model: a dynamic representation of highway traffic consistent with the hydrodynamic theory. Transp. Res. Part B 28 (4), 269–287.

Daganzo, C.F., (1997). Fundamentals of Transportation and Traffic Operations. Pergamon-Elsevier, Oxford, U.K.

Bar-Gera, H. and Carey, M., (2017). Representation requirements for perfect first-in-first-out verification in continuous flow dynamic models. Transp. Res. Part B 100, 284-301.

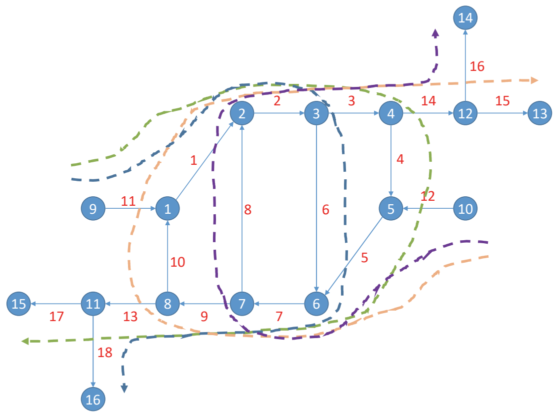

Figure 1: A simple loop network with 4 merging routes.

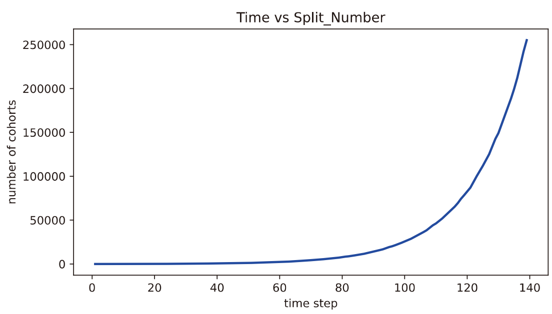

Figure 2: Exponential growth of split traffic.