Modeling Oversaturated Conditions in TRANSYT-7F Release 8

by

Min-Tang Li

University of Florida

In our previous newsletter (Fall, 1997), we described the general new features available in TRANSYT-7F release 8. In this article, we illustrate the kind of spillback effects that can now be modeled in release 8. New objective functions that are specially designed to treat spillback conditions are also introduced.

Simulation Process

The most significant improvement in release 8 is that it allows modeling of networks with oversaturated traffic conditions. Although release 7 accepted networks with these conditions, it did not model them realistically. This is because the simulation process applied in release 7 was not structured in such a way that spillback conditions could be explicitly considered. Release 8 completely restructures the simulation process to address these issues by changing from a link-wise approach to a step-wise approach.

In the link-wise approach, the simulation of the network begins at a specific link, completes all time steps and then proceeds to the next link in turn until all links in the network are simulated. This simulation approach does not allow the effect of spillback occurring over time to pass from one link to another. To remedy this, release 8 introduces a step-wise approach that allows the simulation to proceed through the complete network...
TRANSYT-7F Model

for every simulation time step. With this approach, the spillback effect is passed from one link to another over time. An analogy is to imagine all links lined end-to-end in release 7, to release 8, which resembles a bowling alley with all links being simulated in parallel—with all link-specific interactions being more realistically modeled. In general, execution times for release 8 will be longer than those of release 7, especially for large networks, because of the need to use dynamic allocation of memory to accommodate the memory-intensive nature of the step-wise simulation.

Spillback Effects

Release 8 explicitly considers the following two types of spillback effects:

The saturation flow rate of the thru link is reduced due to blocking by spillover from the adjacent right- or left-turn bay. This is illustrated in the TRAFVU (ITT Systems and Sciences Corporation, Colorado Springs) display in Figure 1 in which the northbound left-turning traffic (shown in the darker shade) spills over and blocks the thru traffic (shown in the lighter shade). To explicitly consider this spillback effect, release 8 allows the user to specify a percentage of reduction to the saturation flow rate for the thru-lane group. Release 7 assumes no saturation flow rate is reduced due to this spillback effect.

The saturation flow rates of the feeding links are reduced due to spillback at the current link. This is again illustrated in Figure 1 in which the westbound traffic between the two intersections spills back to upstream link. Consequently, the southbound right-turning traffic, northbound left-turning traffic and the westbound thru traffic of the upstream links cannot enter the downstream link. In this case, the saturation flow of these turning flows will be significantly reduced. Again, release 8 allows the user to specify saturation flow rate reductions to the upstream links.

Objective Functions for Oversaturated Conditions

TRANSYT-7F optimizes phase lengths and offsets based on an objective function called the performance index (PI). Release 7 included four types of PI defined by disutility index (DI) and/or progression opportunities (PROS). These objective functions were not suitable for optimization of oversaturated networks. Release 8 introduces four additional objective functions that are based on traffic throughput and queuing measures. The “throughput measure” is a ratio defined as the link vehicle departures over link vehicle arrivals. The “queuing measure” is also a ratio and is defined as the average back of queue on a link divided by the maximum number of vehicles that can be accommodated on the link. The idea behind including these measures is to emphasize traffic throughput and queue management to help links with spillback conditions. The new objective functions are:

1. minimizing the product of DI and queuing ratio,
2. maximizing the ratio of throughput ratio to DI,
3. maximizing the throughput ratio and then minimizing DI without reducing the throughput ratio, and
4. maximizing the throughput ratio with a penalty imposed if a maximum v/c ratio threshold is exceeded.
Optimization for Oversaturated Conditions

The following steps may be applied to select the best control strategy for an oversaturated traffic system.

First, the critical link(s) and the type of oversaturated conditions exist in the system need to be identified. A critical link is defined as the most downstream link on a continuous, upstream-downstream list of oversaturated links. The level of congestion in the system as well as the critical links can be determined by performing a TRANSYT-7F optimization run based on minimizing the DI (e.g., excess fuel consumption) with the step-wise simulation. If the system is still found to be congested with the optimal timing, the step-wise simulation with optimization of the DI plus queuing penalty on the links with queue problems should be applied.

Second, if the above process is unable to eliminate the congestion problem, the new objective functions with or without the queuing penalty can be tried. The critical links for which the throughput (or the queuing ratio) is to be optimized should be specified for optimization.

In short, TRANSYT-7F is now a more complete signal timing and traffic analysis tool. It now more realistically examines saturated conditions in addition to its historical modeling of undersaturated conditions.

Reference