A Tour-Based Transit Station Auto Access-Egress Model

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Auto access/egress to/from higher-order transit stations (typically rail, but could also be BRT) is a critical component in suburban transit usage. For example, 55% of Toronto's commuter rail ridership originating outside the city central area on a typical weekday uses a car to access the train station (and, eventually, return home from the station).

Typically, existing models assume a very simple tour, in which suburban commuters drive to a station in the morning, travel into a city central area by rail, and then execute the reverse journey in the afternoon/evening. While this is, indeed, the dominate travel pattern in most North American cities today, as transit systems expand and attempt to compete more effectively with the private car for a wider variety of trips, a more flexible and generalized model of auto access to transit is required to address this evolution. Other factors driving the need for improved models of auto access to transit include:

- The trend towards the use of activity/tour-based models, which require the ability to deal with station choice within arbitrarily complex tour structures.
- The emergence of new mobility services and increasing policy focus on finding improved suburban "first/last mile" solutions for transit services that require a deeper understanding and analytical representation of the transit station access/egress problem.
- Activity/tour-based models also require the ability to model travel behavior over the entire day, not just during the morning and/or afternoon peak periods.
- The need to account for station parking capacities in the determination of access station choice.

The objective of this paper is to develop a tour-based model of drive-access transit station access and egress choice that:

- Recognizes the constraint that if a car is driven to a particular transit station, then the trip-maker needs to return to this station at some point in his/her tour to retrieve the car.[1]
- Allows the trip-maker to insert a "drive to transit station" and a "drive from transit station" at arbitrary points within an arbitrarily complex tour.
- Incorporates transit station parking lot capacities within the model.
- Is computationally efficient.

Figure 1 illustrates the problem to be addressed. In this figure a person has three non-home stops on a home-based tour. A rail line is available for possible use within this tour. Not shown in the figure are the local roads and bus lines that provide connectivity between the tour's trip origins

[1] Rare exceptions to this rule can exist, but are not considered in this model.

and destinations. If the trip-maker has access to a car, its options for executing this tour include (among possible use of transit and other non-auto modes for all trips on the tour):

- Driving on all trips in the tour.
- At some point in the tour, driving from the current activity location within the tour to a rail station, parking the car and taking a train to the next activity location in the tour. At some subsequent point in the tour, the person will have to return by rail (or some other non-auto-drive mode) to the access station and then drive to the next location on the tour.[2]

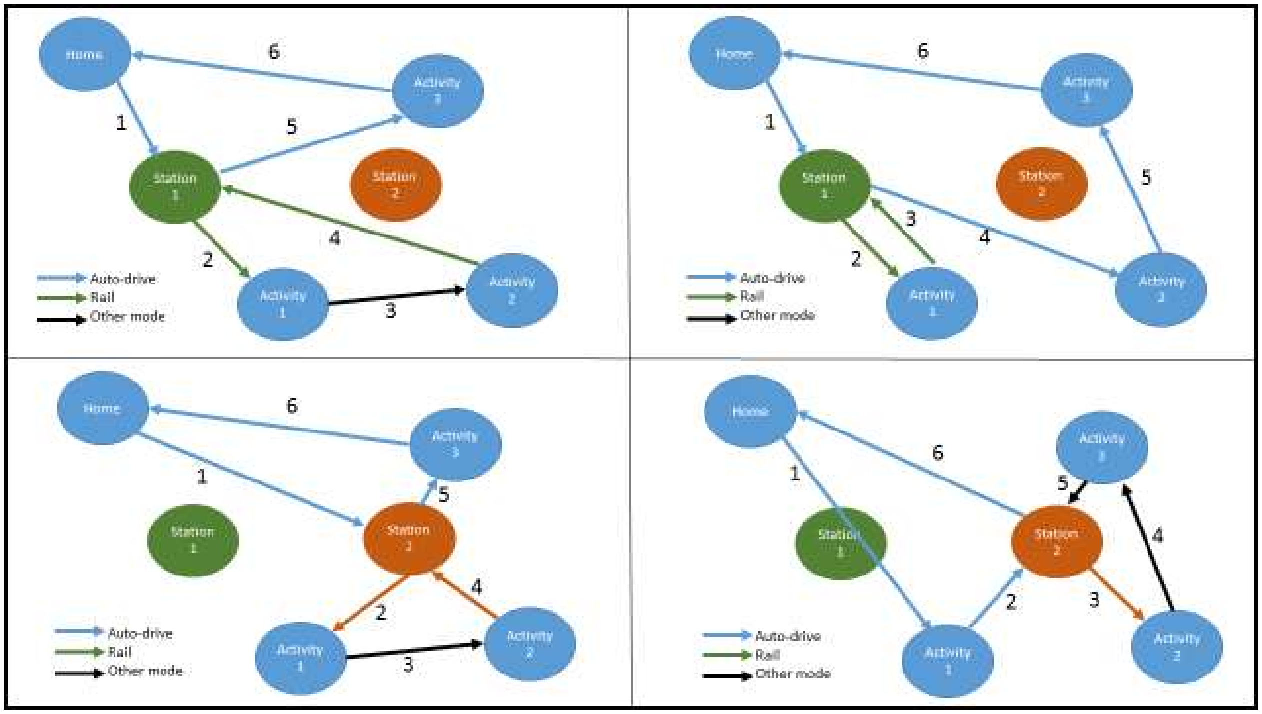

Figure 1. Tour-based auto access to transit Example station choices & tours

The model presented in this paper deals with the problem of predicting the choice of access station, conditional upon choice of the "drive access to transit" (DAT) mode, for every feasible combination accessing and egressing the station within the given tour (examples shown in Figure 1). This station choice model has been developed for implementation within the tour-based mode choice model used within the TASHA activity/travel scheduling model.[3]

The model adopted is a multinomial logit (MNL) random utility model. The systematic utility for each access station is simply a linear function of explanatory variables, where each variable is defined as the sum of the access and egress trip values for the given variable. The final utility function adopted in the implemented model is given by the following equation:

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[2] Note that, although unlikely in most situations, it is conceivable in a very complex tour in an urban region with a very dense rail network two such "auto access to transit" trips might be possible to make. This possibility is not considered in this model.

[3] https://tmg.utoronto.ca/doc/1.4/gtamodel/index.html

$$V_A = \beta_{atime}[atime] + \beta_{cost}\left[acost_A + ParkingCost_{A_x} + tfare_A\right] + \beta_{ptt}[perceivedTransitTime_A] + \beta_{Capacity}[Capacity_A] + \beta_{ClosestStation}[ClosestStation_A]$$

Where (times are in minutes; costs are in 2016 CA$):

atime = auto access+ egress travel time to/from the station.

acost = auto access + egress travel cost to/from the station.

ParkingCost = parking cost at the station.

tfare = transit fare from the station + transit fare to the station on the return trip.

perceivedTransitTime = weighted in-vehicle + wait + transfer + walk times for transit trips from/to the station (expressed in equivalent minutes of in-vehicle travel time)

Capacity = Natural log of the station parking lot capacity (number of parking spaces)

ClosestStation = 1 if this station is the one closest to the trip-maker's home; = 0 otherwise.

The model is also designed to be sensitive to the parking capacity for each station. For the initial iteration the demand for each access station is taken from the observed usage in the 2016 Transportation Tomorrow Survey (TTS) for the region.[4] The inverse of the conical function is used to reduce the attractiveness of a station in each iteration of the model as the parking lot fills up and/or exceeds its nominal capacity, as given by the following formulas:

$$CapacityFactor_A = \frac{1}{2 + \sqrt{\alpha^2(1 - CR_A)^2 + \beta^2} - \alpha * (1 - CR_A) - \beta}$$

Where,

$$\alpha \text{ is a calibrated term similiar to the exponent in the BPR function.}$$

$$CR_A = \frac{Demand_A}{Capacity_A}$$

$$\beta = \frac{2\alpha - 1}{2\alpha - 2}$$

Where "$Demand_A$" and "$Capacity_A$" are the current iteration predicted demand for station A's parking lot and the parking lot's capacity, respectively. This capacity factor is used to scale the utility of logit model probabilities, as follows:

[4] http://dmg.utoronto.ca/transportation-tomorrow-survey/tts-reports

$$P(A) = \frac{CapacityFactor_A * e^{V_A}}{\sum_i [CapacityFactor_i * e^{V_i}]}$$

The coefficients for closest station change depending on the time of day that the access trip occurs.

Table 1. Coefficients by time of day

Variable	Value AM	Value NAM
β_{acost}	-0.133	-0.133
β_{atime}	-0.178	-0.178
$\beta_{capacity}$	0.783	0.783
CapacityFactor	5	5
$\beta_{ClosestStation}$	1.06	1.79
β_{ptt}	-0.0314	-0.0314

The paper defines the problem, briefly reviews the literature, describes the data used, presents model results and discusses its implementation within the TASHA-based operational GTAModel V4.1.