A Novel Model for Transfer Synchronization in Transit Networks and a Lagrangian-based Heuristic Solution Method – Data Description

This document outlines the main data inputs required for our transfer synchronization model. The document is divided into two main sections: data preparation and data description. The data files can be found in the main google drive folder. For further information about this document, contact Zahra Ansarilari on zahra.ansarilari@mail.utoronto.ca.

1. Data Preparation

There are three main types of data inputs described in this section: (1) network features, (2) service and operation, and (3) demand characteristics.

1.1. Network Features

In this section we need some information about the whole network and some other information, specifically about the selected transfer nodes of interest by a user. The first set of information includes the layout of the network, i.e., the total number of transfer nodes, and the sequence of regular stops and transfer nodes for each line/trip. In order to prevent reading huge sets of data, there can be a user input in which they choose the transfer nodes of interest. Then based on the chosen nodes, all the other data sets, not only the network features but also the operation and demand data, will be prepared by Nexus simulation and put as the input data in the main code. In our case we choose 12 transfer nodes to have all the data files for our experiment from Nexus and then choose other instances from those 12 nodes. The second types of network data sets include the transfer pairs (directions) and the associated walking time between feeder and the connecting vehicles at each transfer nodes. The details of mentioned data and their format are explained the next section.

1.2. Service and Operation Data

Other types of data are related to the service and operation which include lines' headways, segment running time i.e., the running times between the stop to stop either there are transfer or regular, and the dwell time of the regular stops. The required dwell/service times of buses at each transfer node is determined in the model based on the number of alighting and boarding passengers. The last service data are the average alighting and boarding time of passengers. In this experiment these values are 1.12 and 1.96 seconds/person, respectively.

1.3. Demand Data

Since we are also considering the capacity limit of vehicles in our model and formulate penalty cost for passengers who lose their vehicle due to lack of capacity, we need a very detailed demand data. The first data set is the number of transferring passengers in each feeder vehicle knowing their connecting line. Second, the number of alighting passengers and the number of local boarding passengers, the ones coming from the street, are also known and given as inputs to the model. Then, the number of in-vehicle passengers, when a vehicle arrives at its first transfer node, is also needed. This value will be determined by the model for the following nodes of a line based on the number of boarding and alighting for that vehicle, so we only need that for the first node. The number of boarding depends on the number of local passenger and the number successfully transferred passengers and the capacity of the vehicle, which all are formulated in the model. Then the required dwell time for a vehicle and accordingly its departure time will be determined based on these calculations; that is why we need a very detailed demand data per vehicle per stop.

2. Required data sets and their preferred structures:

There are 12 data files which contains all the information required in the model for all the 12 transfer nodes. Then based on the chosen transfer nodes for each experiment, the input data for the model should be explicitly prepared before using in the model.

2.1. Network Characteristics, which we get it once.

1. TransferNodeList.csv: the list of all transfer nodes the network.
2. LineSequenceStops.csv: Each line's stop sequence in the network, (Column 1: Line name, other columns: nodes names)
3. LineSequenceNodes.csv: The data is in csv format: column one: line name, the other column are the sequence of nodes based on the order of LineSequenceStops, if the stop is a transfer node, the value is node code, if it is a regular stops the value is -1.
4. LHeadway.csv: Line's headways (average/scheduled or distribution):
   (Column 1: Line name, Column 2: headway)
5. NodeRunningTime.csv: Running time between transfer nodes for each line's nodes sequence (each trip(vehicle) for each day or their distribution):(Column 1: Line name, Column 2: trip number, Column3: Trip order, other columns the travel time in seconds between the nodes in sequence.) Running times between transfer nodes of each line which includes the running times between the regular stops and the dwell times of regular stops if any between each two transfer nodes of a line.
6. TransferPairs.csv: Transfer pairs at each node, (Column 1: the transfer node, other columns lines names two by two are the transfer pairs (from, to))
7. WalkTime.csv: Walking time for each transfer pairs (average or distribution):

(Column 1: the transfer node, other columns lines three by three transfer pairs lines name and the walking time in seconds)

8. Dwell time.csv: Dwell times of each vehicle at each node (average/scheduled or distribution):(Column1: Line name, Column2: node, other columns the dwell time value of a vehicle at a node for all the of trips of that lines)

2.2. Demand Data:

1. NSInVehicleDemand_MultipleNodes: In-vehicle (through passengers, i.e., the number passengers in a vehicle when it arrives at a node) demand,
   (Column1: Line name, Column 2: trip number, other columns the number of in-vehicle passengers arrive at a node, given its sequence, for all the of trips of that lines)
2. NSAlightingDemand_MultipleNodes: Alighting demand,
   (Column1: Line name, Column 2: trip number, other columns the number of alighting passengers for each vehicle arrives at a node, given its sequence, for all the of trips of that lines)
3. NSBoardingDemand_MultipleNodes: Local boarding demand (not successful transferred passengers), (Column1: Line name, Column2: node, Column 2: trip number, other columns the number of local boarding passengers for each vehicle arrives at a node, given its sequence, for all the of trips of that lines)
4. NSTransferDemand_MultipleNodes:Transferring demand, (Column 1: node, Column2: line from, Column3: line to, Column 2: trip number, other columns: number of transferring passengers for each vehicle of line from arrives at a node, given its sequence, for all the of trips of that lines)

Based on the chosen transfer nodes, the lines passing through those nodes will be chosen from the data file TransferPairs. Then, we have transfer nodes of each line in sequence in another file called LineSequenceNodes, while having the data file of LineSequenceStopos which contains all the stops, transfer and non-transfer stops, for each line. So, by now based on the lines involved in the chosen transfer nodes, we will prepare/select the input data for the model based on the other files. For instance, for the running time between each two transfer nodes of a line, we use the information of running times from stop to stop as well as dwell time of regular stops from the NodeRunningTimes and Dwell files, respectively. Obliviously, preparing the data is a an important step, so if further information required please contact me.

The selected node files for some of the experiments are also in the folder. The nodes are shown in figure 1 while their attributes are presented in Table 1. The node IDs in the data set are alos shown in Table 2.

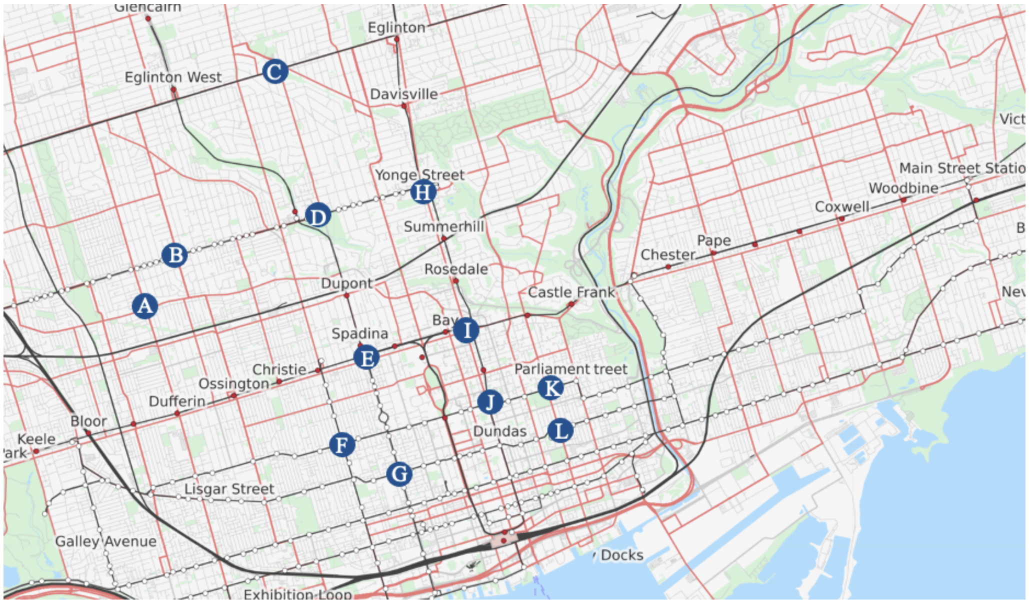

Figure 1. Transfer nodes in downtown Toronto, used in the Case Study

Table 1: Characteristics of Chosen Transfer Nodes from the CTTN

Network Name	Transfer Nodes	Number of Routes	Min, Max, and Average Headway (min)	Number of Transfer Directions	Total Transfer Demand
3NI	K-L-J	10	(4.6) - (30.0) - (9.7)	20	349
3NII	E-G-L	14	(5.0) - (17.0) - (7.9)	24	438
5NI	K-F-J-G-L	18	(4.0) - (30.0) - (8.0)	44	842
5NII	H-D-J-K-B	10	(2.8) - (30.0) - (12.8)	15	229
5NIII	E-A-G-L-K	22	(4.6) - (17-8) - (12.0)	41	683
7NI	J-F-G-L-E-K-H	22	(2.8) - (30.0) - (9.2)	47	886
7NII	J-F-G-L-E-K-D	23	(2.8) - (30.0) - (8.2)	47	864
7NIII	E-A-L-K-D-H-J	21	(2.8) - (30.0) - (11.2)	32	478
9NI	J-F-A-G-L-K-E-H-D	29	(2.8) - (30.0) - (9.7)	56	971
9NII	J-F-G-L-E-K-H-B-I	22	(2.8) - (30.0) - (9.2)	47	886
9NIII	C-E-F-L-K-D-H-J-I	21	(2.8) - (30.0) - (11.2)	38	673
12N	K-E-I-G-F-B-D-H-C-J-L-A	32	(2.8) - (30.0) - (10.1)	59	1004

Table 2: Node IDs

Node name	Node ID in the data set
A	745
B	784
C	519
D	423
E	680
F	302
G	160
H	266
I	362
J	647
K	613

L	549