Documentation of Changi Case Study Calibration Process

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1. Random Trip Assignment Model

Objective

As part of the input files required by the simulation framework, a dataset containing trip information with nodes set as origin and destination needs to be prepared. This dataset can be generated based on an OD estimation matrix which provides the traffic flow data between different strategic zones. Thus this Random Trip Assignment Model aims to assign trips between zones to corresponding nodes within the zones, following some criteria that preserve some randomness as well as take some environmental factors into consideration.

Setting

Available files: Changi MTZ zones, Singapore nodes, Changi establishments data, Changi firm data, OD estimation matrix

Output file: OD data (node)

Scale: Changi area

Methodologies

To produce the required dataset, there are several steps of manipulation we need to implement on the current data we have:

<u>Trip distribution from zones to nodes</u>

Each zone may contain a multitude of nodes. To spread the total number of trips of an entire zone over all the nodes, we would like to be realistic, in terms of respecting the actual distribution of trips, as well as stochastic, so that such distribution is not deterministic. With the data we we have, there are a number of criteria that we can consider:

1. Number of establishments covered by fixed distance buffers
We could create fixed distance buffers around the nodes, and measure the number of establishments that are covered by each node's buffer. Distribution of trips within the zone can be thus proportional to this number of all the nodes within the zone.

2. Number of jobs covered by fixed distance buffers
This method also makes use of buffers centred around the nodes, but relies on the number of jobs as criterion. The job number information is available from the Changi firm data.

3. Number of jobs of the nearest firm
Instead of capturing all the jobs that fall in the buffer region, we could also associate only one nearest firm to each node. Trip distribution can therefore be based on the number of jobs brought about the nearest firm to each node.

The problem with establishment data is that it is not a reliable gauge of the density of goods vehicle traffic flow. Establishments subsume residence area, which might not incur traffic of goods vehicles. The number of jobs, therefore, might give us more information about the likelihood of generating freight trips.

Moreover, after examining the distribution results of using buffers, we found out that it's hard to fine-tune the size of the buffer to strike a balance. Larger buffers will create many double counting of the establishments/jobs because they could be densely distributed in some regions; on the other hand, buffers that are too small will leave a lot of nodes unable to capture any trip because there are simply no establishments/jobs within their buffer region. Thus, to avoid this complication we adopted the third method, which is to distribute trips in proportion to the number of jobs created by the nearest firm of each node.

However we do not follow this ratio deterministically. This distribution of jobs within the zone only serves as a probability benchmark to make our assignment. So node associated with the largest amount of jobs is more likely to assigned a trip starting from/ending at this particular zone. However there is no guarantee that the final distribution of trips will follow the distribution of jobs.

Cross-boundary trips distribution

Some OD trips could be across the Changi boundary, which means either the origin or destination is some region outside the predefined Changi area. To be able to still capture the traffic created by such cross-boundary trips, we appointed several boundary nodes to substitute external zones. Essentially this means any origin or destination that is outside Changi area will be assigned to one of the boundary nodes.

With this setting established, we need a criterion to decide which boundary node we should select for each cross-boundary trip. We compare between two options:

1. Road types

This method hinges on the road type of each boundary node. Here we assume some arbitrary values on each road type such that certain road types are more capable of attracting traffic than the others. For example, expressway might take up the largest proportion of trips, around 60%.

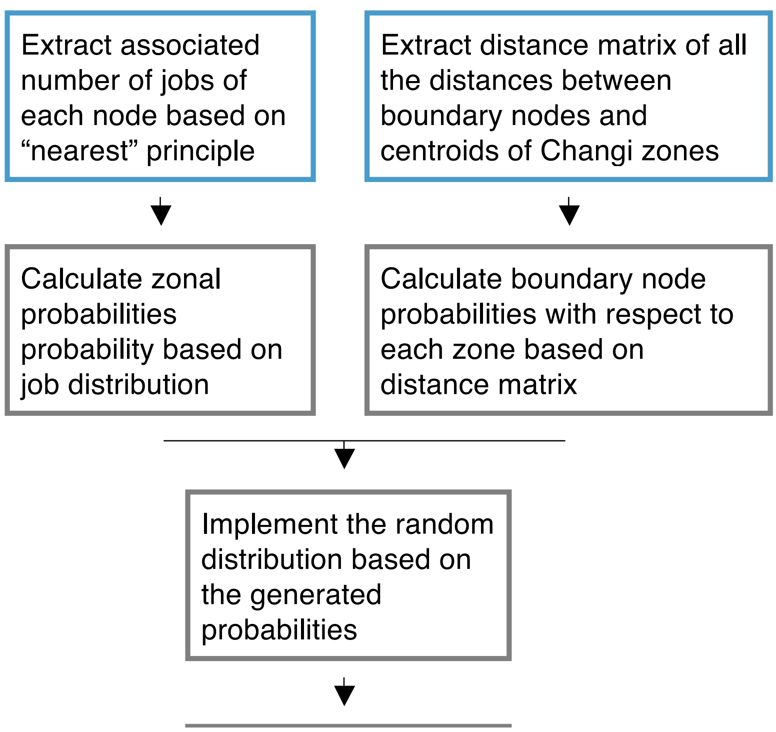
2. Proximity to Changi origin/destination

We could also make a more adaptive decision such that the assignment is determined by which Changi zone the trip starts from/ends in. The probability of assigning the boundary node to the trip is inversely proportional to the distance between this node to the Changi zone.

After some comparisons, the second method proved to be superior in two ways. First, it is able to differentiate each trip to a greater extent so that it's far less crude than the first method. Second, it is a stochastic method that assign the trips based on some prior probabilities.

Implementation Detail

With some of the above key considerations, we were able to build this model with QGIS and R in conjunction. The basic workflow is demonstrated as follow (blue box implemented in QGIS and



grey box implemented in R):

2. OD Matrix Estimation

Objective

To update the LTA provided freight OD matrix for Changi, using the latest available screen line counts (2014).

Methodology:

Please refer to the OD matrix estimation report for the methodology (https://www.dropbox.com/s/981rd89056wsvgo/ODME.pdf?dl=0).

Steps Involved:

1. Run the SimMobility short term with a minimum number of trips between all OD pairsbb in Changi to get the path choice output (path_data.csv).
2. Use the path choice output from SimMobility to derive the path choice probabilities. Use the R code named Finding_Mmatrix.
3. Prepare the input data of counts and Changi OD for the OD matrix estimation problem, using the R code named odme_inputs.
4. Estimate the new OD using the GLS estimator described in the report. For that use python code named gls_wt_obj.

3. Running SimMobility

Objective :

To assign the OD demand to the nodes in SimMobility based on the assignment method discussed in the first section and get the network performance from SimMobility.

Steps Involved:

1. Generate the trip origin node, destination node, and the trip start time based on the method explained in the trip assignment section. Use the R code named Changi_1/2/3 depending on the criteria of assignment to generate the trips. Python code named ODContinuousToXML is used to convert the trips data in csv to XML format.
2. Run the SimMobility short term using the prepared input file and get the output regarding the vehicle counts at each segments from the output file named segment_travel_time.csv

Appendix:

1. Implementation of number of establishments covered by fixed distance buffers + road types (R code: Changi_1)
2. Implementation of number of jobs covered by fixed distance buffers + road types (R code: Changi_2)
3. Implementation of number of jobs of the nearest firm + proximity to Changi origin/destination (R code: Changi_3)
4. OD Matrix estimation report (https://www.dropbox.com/s/981rd89056wsvgo/ODME.pdf?dl=0)
5. Generation of path choice probability matrix (R code: Finding_Mmatrix)
6. Preparation of Input data for the OD matrix estimation (R code: odme_inputs)
7. Solving the OD estimation problem (python code: gls_wt_obj)
8. Preparing the input to run the SimMobilty (python code: ODContinuousToXML)