Local accessibility to transit stops: a new method for defining centroid connectors

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1 Introduction

Accessibility is a key concept in transport project studies and especially in transport demand modelling, travel behavior analysis and transport investment appraisal. It is generally computed from the travel time cost functions between origins and destinations. In transport models, those origins and destinations are frequently aggregated into traffic zones or, the so-called, Traffic Analysis Zones (TAZ). Therefore, all the different origins and destinations lying inside a zone are concentrated in a unique node called zone centroid which is connected to the network through centroid connectors. That is, the zoning system introduces a bias in the estimation of accessibility (Chang et al., 2002; Sean Qian and Zhang, 2012). This approximation has always been imputable to data availability and computational issues.

Nowadays, the increasing availability of spatially detailed data offers the opportunity to refine transport modelling and especially the local accessibility characterization. Some surveys have accurately collected trips origins and destinations in order to describe the local access to the network and the amenities around. This has led some researchers to bypass the aggregation bias introduced by the zoning system and to work with a totally disaggregated or individual-centered approach (Chapleau and De Cea, 1983). Some other researchers have attempted to reduce the impact of the aggregation and especially the use of centroid connectors by introducing probabilistic network access functions (Leurent et al., 2011). These approaches are still, however, not widespread due to their complexity. Overall, most surveys protocols continue to collect data using census tracts. The question then of defining the centroid connectors remains of great matter to the modelling of transport.

2 Objectives and assumptions

In transport models, all trips are considered to start and to end at the centroid nodes. In reality, these origins and destinations are spatially distributed within zones. Therefore, the standard definition of zone connectors based on the position of centroids does not reflect the local conditions of accessibility to the network. For this reason, centroid connectors could have significant impacts on the main outputs of transport models and particularly on the outcome of the traffic assignment procedure (Chang et al., 2002; Sean Qian and Zhang, 2012).

This is particularly the case of the public transport system for which the walking time to transit stops represents a relatively large share of the travel time. Besides, in most models, walking time is often penalized because it is considered more painful for users than the in-car time. The coding method of transit connectors is therefore an important issue in the estimation of travel time functions and consequently of the accessibility. Lastly, it goes without saying that defining connectors can also be time consuming. That is why, we propose, here, a new automatic method for coding transit connectors which relies on fine spatial scale databases.

To address this issue, we will test two assumptions:

1. The outputs of transport models and particularly the transit load volumes and travel time distribution are expected to be dependent on the definition of centroid connectors;
2. Using fine resolution databases may improve the goodness of fit of these models.

3 Method and data

The study area for this research project is the urban area of Lyon (France) for which we have developed a multimodal transport model (Nicolas et al., 2013). Using this model, we will measure the impact of the connectors coding method on the outputs and especially on the accessibility estimates and propose, ultimately, an automatic method with the aim to reduce this impact.

Regarding the first assumption, we have performed a stress test to highlight the influence of transit connectors coding method on the outputs of transport modelling. The experience protocol consisted of series of sensitivity analysis. In each analysis, we changed the connector's definition and ran a transit demand assignment. As expected, transit load volumes and accessibility estimates are indeed dependent on the coding method of transit connectors. In order to reduce this impact, we have developed an automatic coding method based on the recent release of spatially fine resolution databases.

The main idea of this new method is to implement the original definition of zone connectors, namely, rendering the average local access and egress conditions to and from the network. This method is based on the following steps:

1. For each zone or TAZ, we select transit lines that are considered accessible from the corresponding zone. Then for each selected line, we identify the transit stops that are considered accessible from the corresponding zone;

2. For each zone and each selected transit stop, we compute the distribution of walking distance from each building in the catchment area of the transit stop;

3. For each zone and each selected transit line, we define a weighted function that averages the distribution of distances (step 2) from each transit stop considered in step 1. We assign the average distance to the connector of each line considered in step 1.

To do so, four databases (population census, firms' census 'SIRENE®', localized tax database and building characteristics database 'BD Topo®') are combined to create ultimately a new database of located residential population and jobs at the building level of resolution. Within a GIS tool, we compute walking distance between the population and jobs located in each building and the public transport stops. A transit stop is considered accessible from a building (respectively from a zone) if it is within a certain walking distance from this building (respectively from a building lying within this zone). A transit line is considered accessible from a zone if it serves an accessible transit stop. At this point, each zone has, for each accessible transit stop, a distribution of the walking distances which is made up of the different computed distances between the buildings belonging to this zone and the corresponding accessible transit stop. Since, the population (residential population and jobs) lying near a transit stop is more likely to use the transit system than far population, the weighted aggregation procedure uses a distance-decay function. We test different weighted functions. Hence, the average distance assigned to the transit connector renders quite accurately the local conditions of access and egress to transit facilities.

4 Coming results

The application of this new method to the case of the Lyon urban area and its multimodal transport model allows us to examine the contribution of such a coding approach. We will particularly focus on the effects of connectors on transit assignment outputs and travel time distribution. We will also report the impacts on the accessibility estimates. Finally, to assess the global enhancement introduced to the goodness of fit of the model, a comparison with some observed load volumes of the Lyon transit system is expected.

Keywords: transit accessibility; walking distance; centroid connectors; transport modelling; spatially detailed databases.

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