Transit Planning with Spontaneous Accessibility

Public Transit Analytics (https://publictransitanalytics.com)

Transit planners rely on measurements and projections to make prudent changes to transit networks. Though a variety of models exist for calculating the value of the network, they share an emphasis on optimizing the transit network based on the expected behavior of riders. Spontaneous Accessibility is a concept that quantifies the ability of individuals to take unexpected, unanticipated trips. With Spontaneous Accessibility, planners can design networks that extend the benefits of private vehicle ownership to those without a car. Furthermore, these measurements can be computed quickly, need minimal data for their computation, have the precision to detect the impact of minor changes, and are easily visualized for performing public outreach.

A New Measurement

A key component of transit planning is a network model for testing proposed changes. Many large-scale transportation planning decisions make use of the Urban Transportation Modeling System, which uses a four-step model consisting of trip generation, trip distribution, mode choice, and traffic assignment (Pas, 1995). Proposed modifications of the transit network are evaluated based on their ridership impact to the modeled network. Critics of this model believe that it does not measure the network from the perspective of the individual, and thus fails to recognize that a trip only happens because an individual is trying to fulfill a need (Hägerstand, 1970). Accessibility-based measurements provide an alternative where this is the focus (Hanson, 2004). These models have been used for planning studies ranging from analyzing the ability of individuals to reach jobs (Owen and Levinson, 2012) to choosing development sites in shopping centers based on the ability of individuals to reach them using transit (Arce-Ruiz et al., 2012). Studies using either model typically allocate service based on predicted demand. This is implicit in the four-step model, as origins produce a predicted number of riders and destinations attract them. It is explicit in many accessibility-based evaluations: they are typically framed around expected trips, such as how well the transit network allows access to jobs during the typical morning rush hour.

While improving performance for predictable trips is important, the popularity of private vehicles is, in part, a result of them enabling an immediately response to unexpected events. A scheduled transit network is at a disadvantage in this case. With a way to quantify the capability of the transit network to support such trips, however, planners can make incremental improvements, gradually allowing the transit network to extend more of the benefits of car ownership to those without one.

Spontaneous Accessibility quantifies the ability to make unexpected, unanticipated trips within the service area of a transit agency or the boundary of a municipality. It accounts for the need to travel at any time of day and from completely arbitrary origin and destination points. To accomplish this, the area is divided into a set of non-overlapping, uniformly-sized Sectors. The planner then selects a duration to serve as an isochrone threshold: the longest time that an individual will allocate for a trip. Using each minute in the day as starting times, and the center of each Sector as origins, an algorithm determines which Sectors can be reached within the duration by walking and taking transit. This process uses full transit schedules and models walks between transit stops and from stops to arbitrary Sectors with accurate walking paths. The Network Accessibility Ratio of a transit system, the principal Spontaneous Accessibility measurement, is calculated by summing the reached Sector counts for each starting time and location, and dividing it by the hypothetical maximum reachability. This is shown in Equation 1 where T is the set of all time samples, S is the set of Sectors, and $reached$ is a function that computes the number of Sectors reached in the duration for a starting point and starting time.

$$NAR_{duration} = \frac{\sum_{t \in T} \sum_{s \in S} reached(t, s)}{|T| \cdot |S|^2} \quad (1)$$

How to Use It

Spontaneous Accessibility is measured as a dimensionless ratio, so it is most useful for making comparisons. It suits planners well when considering the impact of changes

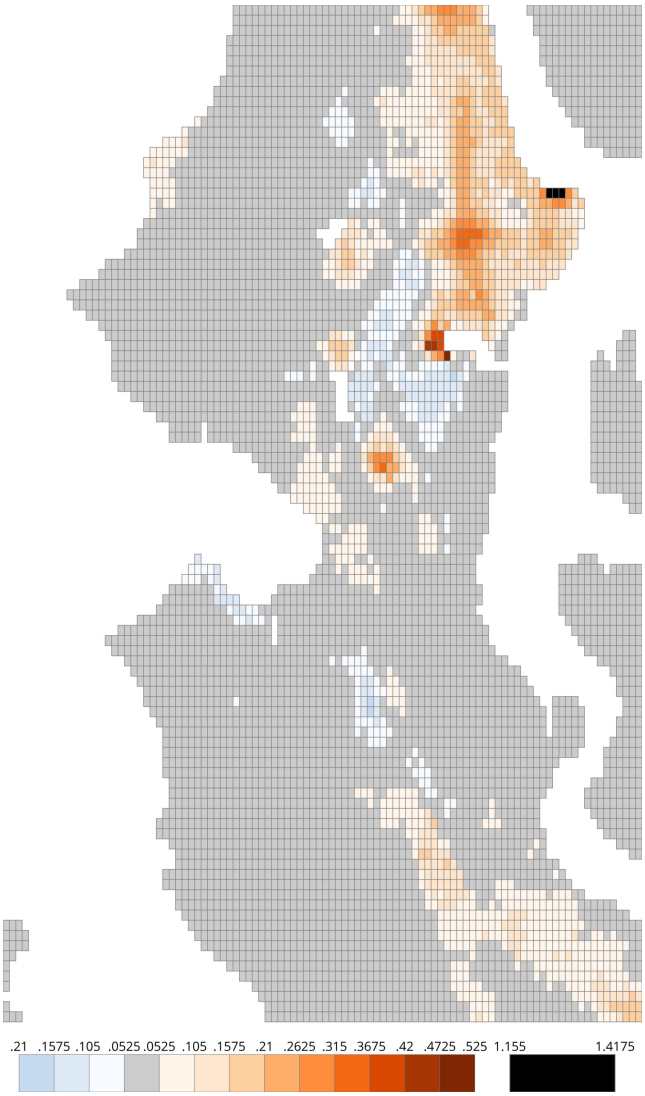

Figure 1: *A comparative Network Accessibility map.*

or comparing alternatives. It requires few materials to calculate: schedules in General Transit Feed Specification (GTFS) format, OpenStreetMap road data, and optionally, geographic survey data of bodies of water.

Initially, the Network Accessibility Ratio is calculated on the present state of the network. Along with the ratio, this calculation produces a Network Accessibility map. This map, useful for understanding the current accessibility of the network, treats each Sector as a destination. Sectors are colored based on the proportion of starting location and starting time pairs in which it can be reached in under the duration threshold.

The planner then makes changes to the schedule and recalculates the Network Accessibility Ratio, giving them a measurement of the overall change. The outputs of the original and modified calculations can be used to generate a comparative Network Accessibility map. Each destination Sector shows the change in the proportion of scenarios wherein it can be reached, demonstrating the distribution of impact. This map helps during public outreach, as individuals can see the change in accessibility of areas that they care about. If a planner is considering many alternatives, it is possible to reduce the calculation time by using only a sample of Sector centers as origins. Techniques from information theory are used to generate representative samples.

The example of a comparative Network Accessibility map shown in Figure 1 presents the change in Spontaneous Accessibility that resulted from opening two light-rail stations and performing two localized bus restructures in Seattle. It illustrates that Spontaneous Accessibility measurements have the precision to demonstrate the impact of incremental changes, not just the ones proposed as a result of long-range planning.

Measuring Spontaneous Accessibility is primarily intended to supplement the modeling tools available to planners. It lacks a capacity-based view of the transit network that some other methods provide. Nevertheless, it measures an important quantity that these technologies do not account for. By ensuring that network changes are made with Spontaneous Accessibility in mind, transit planners can make network improvements that gradually close more of the gap between public transportation and private vehicle ownership. As such it should be a valued tool in a planner's collection.

References

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