The Metropolitan Chicago Accessibility Explorer

Final Report

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1 Introduction

Accessibility refers to the ease with which one can reach opportunities. It combines measures of mobility and land use and allows us to see what people can get to rather than how far or with what speed they can travel. Though accessibility and mobility are related ideas, they are not synonymous. As Handy (2002) points out, places of high mobility may have low accessibility on account of the built environment and places of high accessibility may have low mobility on account of substantial congestion. In addition to land use and mobility factors, accessibility measures can also include temporal and individual dimensions as pointed out by Geurs and VAn Wee (2004).

There are various reasons to study accessibility. One is the view that it is not mobility per se that should be the focus of transportation policies but the activities that can be reached. The view of travel as a derived demand is consistent with this view —why travel except for what you are trying to get to? Policy thus should focus on connecting users to as many opportunities as possible rather than focusing on the mobility aspects of travel alone. This forces us to think about not just the transportation system, but also about land use and how the two work in tandem (see for example, Tilahun and Fan (2014) for an application).

There are also other important reasons for studying accessibility. Several authors have looked at accessibility and labor market outcomes and found a connection, particularly for lower income households. Though evidence is mixed, many have found some aspects of accessibility to be related with employment outcomes (e.g. Sanchez (1998); Thakuriah and Metaxatos (2000); Berechman and Paaswell (2001); Kawabata (2003); Ozbay et al. (2006), reduced welfare usage (e.g. Blumenberg and Ong (1998)), differences in employment rates (e.g. Ihlanfeldt and Sjoquist (1990); Ihlanfeldt (2006)), as well as with commute outcomes (e.g. Levinson (1998)).

A regional look at accessibility allows us to understand urban areas as experienced by their residents. Questions about what activities can be reached by residents of a specific neighborhood in reasonable time by a given mode; changes to accessibility over the course of a day as transit systems adjust their schedules to demand; the spatial equities (or inequities) of transportation availability; as well as changes to accessibility over time as jobs and residences shift or as transportation networks change and whom these changes impact can all be visualized in ways that are easily understood.

In summarizing the different ways of measuring accessibility, El-Geneidy et al. (2006) identify five methods —the cumulative opportunities measure, the gravity type accessibility measure, utility based accessibility measures, constraints based measures, and composite measures. Each measure offers advantages (and disadvantages). Particularly focusing on the first three, one can see that the cumulative measure is the simplest and has the advantage of being easily interpretable. The gravity based measure appropriately discounts opportunities that are further away than closer ones with meaningful impedance/cost measures. The utility based measure has strong theoretical foundations and allows the analyst to attach values to accessibility in a way the other methods don't. As one moves from cumulative measures to others, the intuitive interpretation of the accessibility numbers declines and complexity of the measurement process increases.

Our goal in this project is to provide an online platform that allows users (planners, transportation professionals, policy analysts, etc.) to measure accessibility for the metropolitan area of Chicago and to present the information in the most easily interpretable fashion. We thus adopt the cumulative opportunities measure as our main tool for the measurement of accessibility.

The cumulative opportunities measure reports counts, area, etc. of different oppor-

tunities or land uses that can be reached from every origin in the region within some pre-specified travel times (for example, how many manufacturing jobs can you reach within a 30 minute travel time of a given location?). The measures are simple and easily understood. They are presented for a range of opportunities (jobs, parks, schools, groceries, etc.), and at different time thresholds ranging from 5 minutes to 60 minutes. For transit systems, accessibility is measured for different times of day, reflecting changes in service over the course of a day. The presentation of the information also allows users to collect data from their location of interest by simply pointing their cursor at it. The goal is to enable a view of accessibility that can be as macro or micro as the analyst wishes it to be.

To enable this, a variety of tasks have been undertaken ranging from developing measures of travel time for all origin destination pairs in the metropolitan region for automobile, transit, walk and bike modes, to collecting data from a variety of agencies about land use, and integrating them using a variety of open source tools that are available for organizing as well as presenting this information. In Section 2, we will discuss the methodology that was followed in more detail. Section 3 discusses the technical details of implementation as well as the data sources. Section 4 discusses the final product. Finally, section 5 presents future plans for the Metropolitan Chicago Accessibility Explorer[1].

[1]The Metropolitan Chicago Accessibility Explorer can be accessed at http://www.urbanaccessibility.com

2 Methodology

There are multiple ways to measure accessibility. In this project, we used the simplest method—the cumulative opportunity measure—to demonstrate regional accessibility by different travel modes. The cumulative opportunities measure counts the number of opportunities (e.g. jobs) that can be reached in some travel time threshold (e.g. 45 minutes) by a particular mode (e.g. automobile, transit). Accessibility for a given threshold by a particular mode can be calculated as a simple sum of all opportunities in block groups that can be reached within the predesignated time threshold. Mathematically, leaving mode and threshold indexes for simplicity, this can be written as:

$$A_i \ = \ \sum_{j=1}^{J} O_j \ f(T_{ij})$$

where:

A_i: Accessibility at block group i to activity type O

O_j: Opportunities available in block group j

$f(T_{ij})$: A function that takes a value of 1 or 0 based on whether the travel time from i to j (T_{ij}) is within a given time threshold (1=Yes, 0=No).

For every origin block group in our analysis area, this measure was computed for four modes (automobile, transit, bicycling and walking) to different destination types including jobs, parks, schools, groceries. For each mode accessibility is computed in 5 minute increments showing what can be reached from every origin in travel times ranging from 5 minutes to 60 minutes. Further, transit accessibility is computed for different departure times through out the day capturing the changes in service and, as a result, accessibility through the course of a day. Depending on the opportunity

type, the analysis area changed, due to lack of data for some opportunities. For Jobs our analysis area is the metropolitan region of Chicago. For other opportunities, we currently only compute accessibility for the block groups in the City of Chicago. This is mainly because the land use data (O_j in the accessibility formula above) is not completely available for all locations in the metropolitan area at this time.

A full accounting of the methodology and process of the development of the tool is given in Yin et al. (2015).

3 Data Sources & Implementation

Multiple data sources were used to calculate the various accessibility types the Accessibility Explorer provides. These include accessibility to jobs in general, jobs by sector, earnings and other classifications, and accessibility to points of interest such as parks, libraries, schools, fire stations, hospitals and grocery stores. These accessibilities are provided at different time thresholds ranging from 5 minutes to 60 minutes separated by different travel modes. Accessibility measures are computed using census block group geographies which provide a fairly detailed resolution to assess how well connected a location is to different activities or opportunities. Block group definitions correspond to those used in the 2010 decennial census.

Part of the accessibility data —transit accessibility to jobs —came from the University of Minnesota's Accessibility Observatory[2]. The travel time for transit from the Accessibility Observatory was calculated from the centroid of each block group to all blocks in the metropolitan area along a combined pedestrian and transit service network that reflects schedule times as published by transit providers in the region[3]. Job accessibility is computed for Cook, DeKalb, DuPage, Grundy, Kane, Kendall, Lake, McHenry, and Will counties in Illinois. Automobile accessibility to jobs as well as automobile, transit, and pedestrian accessibilities to the remaining activities were computed using data sources and processes described below.

[2]Accessibility Observatory. http://access.umn.edu. Accessed January 15, 2015

[3]The pedestrian network is derived from the public OpenStreetMap (OSM) database as of April 16, 2014. It includes all OSM features with the "footway," "pedestrian," and "residential" tags. The transit network is derived from GTFS-format schedules published at metrarail.com, www.chicagotransit.com, and www.pacebus.com. These reflect METRA, CTA, and PACE transit service as of January 2014.

3.1 Data Sources

As described in the Methodology section, the inputs to the accessibility matrix are travel times for different modes (in this case block group to block group) and the opportunities or land uses that one wishes to compute access to. The data on opportunities/land uses came from a combination of sources. The number of jobs by sector data is from the Longitudinal Employer-Household Dynamics (LEHD)[4] compiled by the United States Census Bureau. Other land use data besides employment was collected by requesting shapefiles from each metropolitan county's GIS Department or GIS specialist. We also used the City of Chicago's Data Portal[5] to collect data specific to the City. Due to data limitations or unavailability, not every type of land use data is available for all counties. A summary of the data availability is shown in Table 1.

Other types of data that were used in the project include network data for the region to compute travel times. These employed Open Street Maps (OSM)[6] and publicly available General Transit Feed Specification (GTFS)[7] data for the metropolitan region.

3.2 Implementation

OpenTripPlanner (OTP)[8] was used to calculate travel time from each block group to all other block groups. OTP is an open source platform for multi-modal and

[4]Longitudinal Employer-Household Dynamics. http://lehd.ces.census.gov/data/ Accessed February 1, 2015

[5]City of Chicago's Data Portal. https://data.cityofchicago.org Accessed February 1, 2015

[6]©OpenStreetMap contributors. http://www.openstreetmap.org Accessed January 15, 2015

[7]GTFS/Scheduled Service Data. http://www.transitchicago.com/developers/gtfs.aspx Accessed January 15, 2015

[8]http://www.opentripplanner.org Accessed January 15, 2014

Table 1: Availability of accessibility type in each county

Measured Accessibility	City of Chicago	Cook County	DuPage County	Kane County	Kendall County	McHenry County	Lake County	Will County
Jobs	✓	✓	✓	✓	✓	✓	✓	✓
Parks (area)	✓							
Parks (count)	✓	✓	✓	✓	✓	✓	✓	✓
Libraries	✓		✓	✓	✓	✓	✓	✓
Fire stations	✓		✓	✓		✓	✓	✓
Schools (all)	✓	✓		✓		✓	✓	✓
Private schools	✓	✓						
Public schools	✓	✓						
Hospitals	✓	✓		✓		✓	✓	✓
Groceries	✓							✓

multi-agency trip planning written in Java. We used a library called `[otp-jython]`[9] to write Python scripts to do batch processing via Java-written OTP.

In summary, the process is as follows:

- using OTP, together with OSM data and GTFS data, to create a multi-modal transportation network.
- writing Python scripts that make use of `[otp-jython]` calculate travel times.
- writing Python scripts to calculate the counts of reachable opportunities, based on travel times using the formula showed above
- writing Python scripts to calculate accessibility as a percentage of all opportunities.

Once accessibility is calculated, it was then converted to JSON files. Each JSON file stores accessibility values (actual number and percentage) to one type of opportunity by a certain transport mode at a certain time of a day within a certain threshold. Also converted to JSON files are travel times, each containing travel time from a block group to all block groups by a certain transport mode at a certain time of a day.

3.3 Rendering Layers

The deployment used:

- Leaflet[10] and Mapbox[11] for online map service and javascript API.

[9] https://github.com/mattwigway/opentripplanner-jython written by Matthew Conway. Accessed January 15, 2015.
[10] http://leafletjs.com Accessed January 15, 2015.
[11] https://www.mapbox.com Accessed January 15, 2015.

- Amazon EC2[12] for hosting.
- Flask[13] as our framework, providing scalability for future expansion.

For more on the development of the tool, please refer to Yin et al. (2015).

[12]http://aws.amazon.com/ec2/ Accessed January 15, 2015.
[13]http://flask.pocoo.org Accessed January 15, 2015

4 Product

Current implementation of the Metropolitan Chicago Accessibility Explorer is deployed at http://urbanaccessibility.com. The Explorer has three views: Accessibility view, Travel Time view and a Combined view.

In Accessibility view, users have the ability to look into different accessibility measures for the Metropolitan area depending on data availability on activity locations. A user would first choose to what type of opportunity they are interested in looking at accessibility. The options include: jobs, parks (by count or area), schools (private, public, both), grocery stores, hospitals, libraries, and fire stations. The most expansive coverage is available for jobs while some are limited to the Chicago area only.

Users are also allowed to select which travel mode they are interested in. Four options are available: Auto, Transit, Bicycle and Walk. The choice of Transit presents further choices to the user. Transit schedules and travel times can vary considerably by time of day as operators try to scale operations to demand. As a result, what is reachable in 30 minutes at 8 am, for example, may not be reachable at 8pm. We therefore offer the user the option to look at time of day changes to accessibility by selecting different departure times.

Job accessibility is available for multiple classes of jobs. One can select job classes separated by industry, corresponding to the 20 two-digit North American Industry Classification System (NAICS) classes [14]. In addition, jobs accessibility can be visualized by different demographic characteristics as presented in Work Area Characteristics files presented by the Longitudinal Employer-Household Dynamics (LEHD) data. These categories include age, race, ethnicity, earnings, gender, and education

[14] See http://www.census.gov/cgi-bin/sssd/naics/naicsrch?chart=2012 for these classes.

level.

Other accessibilities as currently implemented apply to a smaller geography than for jobs. This is primarily because the data based on which accessibility can be computed has gaps as can be seen from Table 1. For that reason, we have opted to include maps for the City of Chicago, with the goal of updating the accessibility maps as more complete coverage can be found.

As currently implemented, the visualization of accessibility uses by default the Jenks natural breaks classification method (Jenks, 1967) to cluster block groups into 7 classes, and rendered them using a monochromatic green color scheme. Also available is to cluster block groups using a fixed scale (i.e. 0%-10%, 10%-20%, etc). Users are also able to bring up CTA and Metra lines, as well as Chicago community area boundaries, onto the map for easier reference of location. CTA and Metra lines and community area boundaries are GeoJSON files converted from shapefiles. In each of these cases, users interested in measuring accessibility at any given location can hover their mouse at the point of interest and read detailed information about the block group, including the number of accessible opportunities, the accessibility value, the community area it belongs to, and the total number of currently selected opportunity. Along with the user provided inputs on mode, time threshold, activity type, this information allows the user to gather information to allow comparative analysis of a place for different purposes (e.g. job classes) or for different geographical locations.

In Travel Time view, users click mouse in a block group after picking a transport mode (and a departure time if transport mode is Transit) to see travel time from that block group to all other block groups visualized as isochrone maps. Same as in Accessibility view, users can hover their mouse at the point of interest and read the travel time needed from the origin block group to this point.

In Combined view, the accessibility map and travel time map are shown side by side, allowing users to see both visualizations together. This view makes it easier for users to visualize the areas within which land use change can be made to affect accessibility. It also makes it easier to see the geography over which particular accessibility measures are computed for any area of interest.

5 Future directions

The Metropolitan Chicago Accessibility Explorer is primarily geared to make it easier to use of accessibility in making decisions about transport or land use related change. In its current form, it enables one to perform a comparative assessment of how well a place is connected to opportunities —jobs, schools, groceries, etc. The next step is to allow users to assess potential locations to which they can attract jobs, groceries, or other types of land uses with the goal of increasing accessibility to different areas of the region. This will require, given one knows the location they are interested in, the creation of maps that show what areas can be reached in some time threshold. Our goal is to provide an interface that is able to do this in an easy and speedy manner. Second, the current system allows users to manually look at particular locations and read off accessibility values. In future iterations, we aim to enable selection (e.g. by drawing polygons) and enable users to download reports from the interface that has been created.

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