

Transportation Networks & Land Use:

GGR424 - Transportation Geography & Planning

Jeff Allen

University of Toronto

February 7, 2022

Land Use

Urban Form

Built Environment

Urban Spatial Structure

In transportation geography and planning, we are usually working with **vector** data (rather than raster data)

Land Use Data

- ▶ What is located where
- ▶ Usually **Points or Polygons**

Network Data

- ▶ The spatial patterns of transportation networks
- ▶ Usually **Lines** (and nodes/intersections)

Travel Data (more on this next week)

- ▶ Travel Surveys (usually tables, linked to locations)
- ▶ GPS/Sensor Mobility Data (usually big N point data)

Land Use Data

- ▶ What is located where
- ▶ Usually Points or Polygons
- ▶ Many data sources, e.g. OpenStreetMap

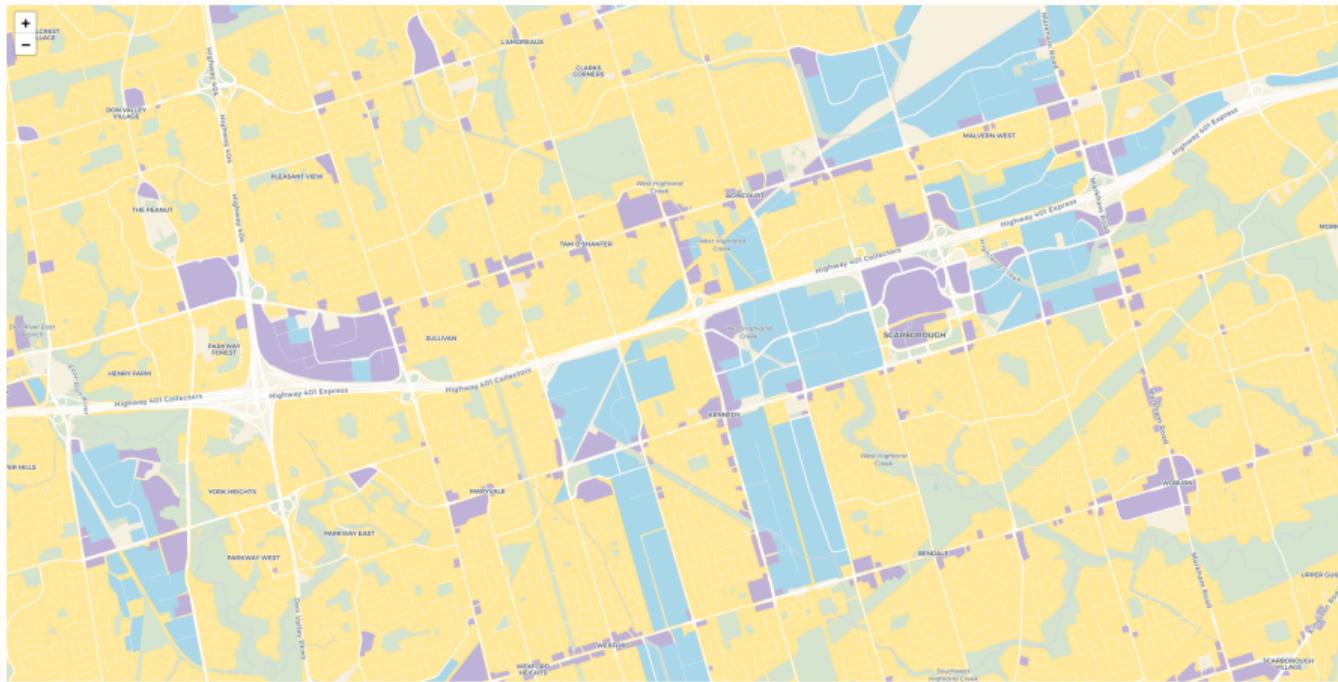
The screenshot shows a web-based map editor called Overpass Turbo. The map displays the city of Toronto, Canada, with a grid of streets and various geographical features like water bodies and parks. Numerous yellow circular markers are scattered across the map, primarily concentrated in the downtown area and along major thoroughfares, representing the locations of cafes. The Overpass Turbo interface includes a top navigation bar with links for Run, Share, Export, Wizard, Save, Load, Settings, Help, and a search bar labeled "overpass turbo". On the left side, there is a code editor window containing an Overpass query. The query is as follows:

```
1 /*  
2 This has been generated by the overpass-turbo wizard.  
3 The original search was:  
4 "cafe"  
5 */  
6 [out:json][timeout:25];  
7 // gather results  
8 !  
9 // query part for: "cafe"  
10 node["amenity"]="cafe"!{{bbox}};  
11 way["amenity"]="cafe"!{{bbox}};  
12 relation["amenity"]="cafe"!{{bbox}};  
13 !  
14 // print results  
15 out body;  
16 >;  
17 out skel qt;
```

In the bottom right corner of the map, there is a status bar with the text "Located - nodes: 1042, ways: 33, relations: 0" and "Displayed - points: 827, lines: 0, polygons: 33".

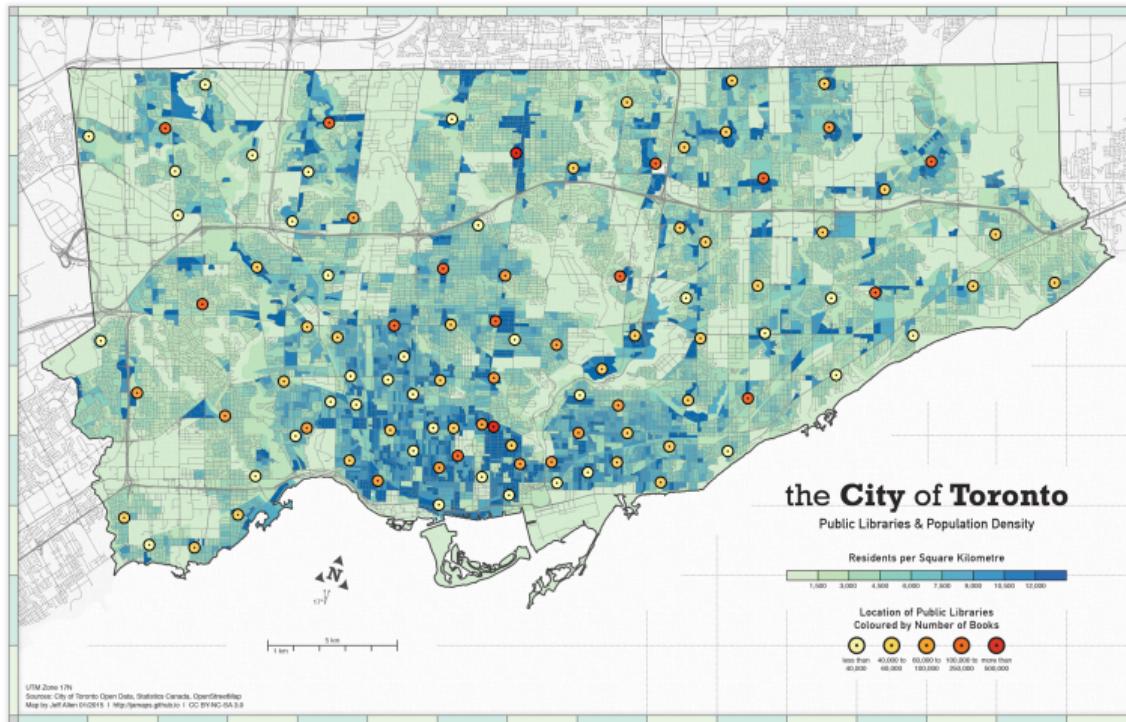
Land Use Data - e.g. polygon data

yellow = residential, purple = retail/commercial, blue = industrial, etc.



Land Use Data

e.g. polygon data - census data, who lives and works where
e.g. point data - libraries in Toronto



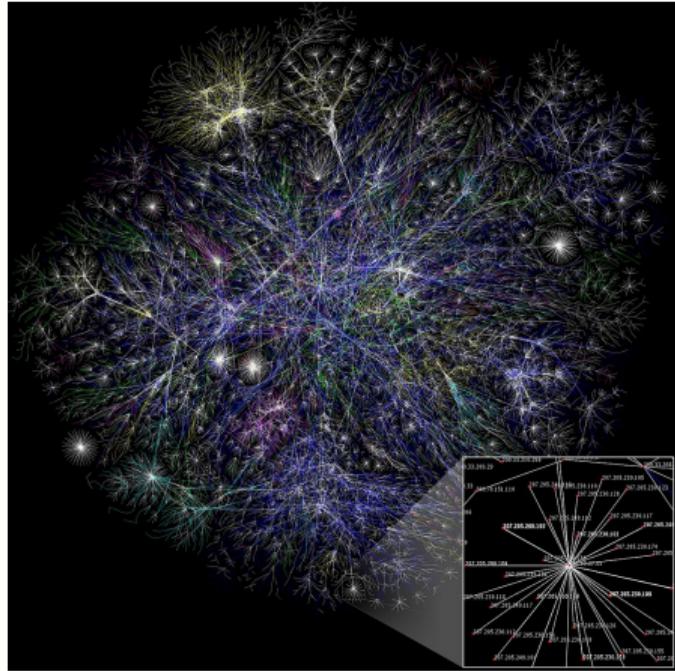
Network Data:

Network - an interconnected group or system

Examples

- ▶ Computer network
- ▶ Social network
- ▶ Transportation network
- ▶ Biological network

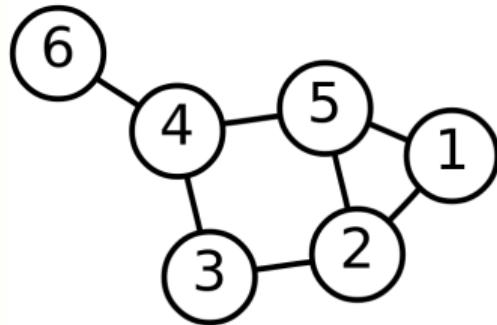
Often represented using **graphs**



Source: https://en.wikipedia.org/wiki/Network_science

Graph

- ▶ Set of *nodes* (also called points or vertices) and *edges* (also called lines or arcs)
- ▶ $G = (V, E)$
- ▶ If two nodes have a relationship, then there is an edge linking them
- ▶ Edges can have weights (e.g. travel time or speed, surface quality, elevation, etc.)
- ▶ Graphs can be directed or un-directed (e.g. can have one-way relationship)



Source: [https://en.wikipedia.org/wiki/Graph_\(discrete_mathematics\)](https://en.wikipedia.org/wiki/Graph_(discrete_mathematics))

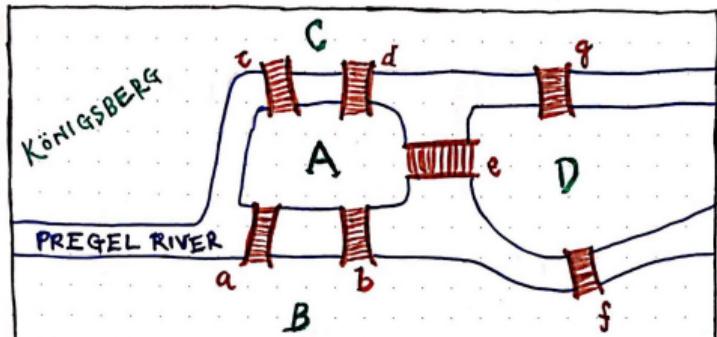
Can you walk across all of the seven bridges in Königsberg, without ever repeating a single bridge in the course of one's walk? (Leonhard Euler, 1736)



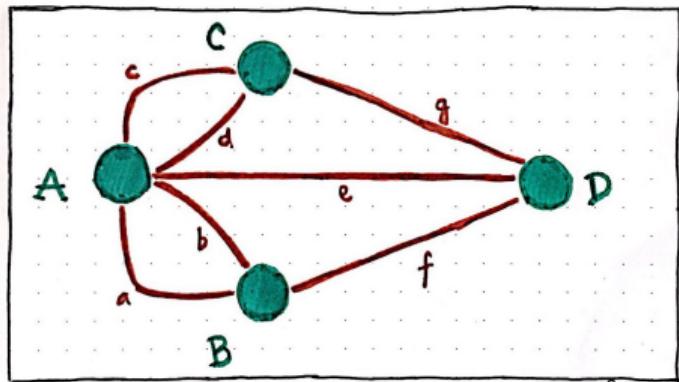
Source: <https://medium.com/basecs/konigsberg-seven-small-bridges-one-giant-graph-problem-2275d1670a12>

Can you walk across all of the seven bridges in Königsberg, without ever repeating a single bridge in the course of one's walk? (Leonhard Euler, 1736)

Representing Königsberg as a graph

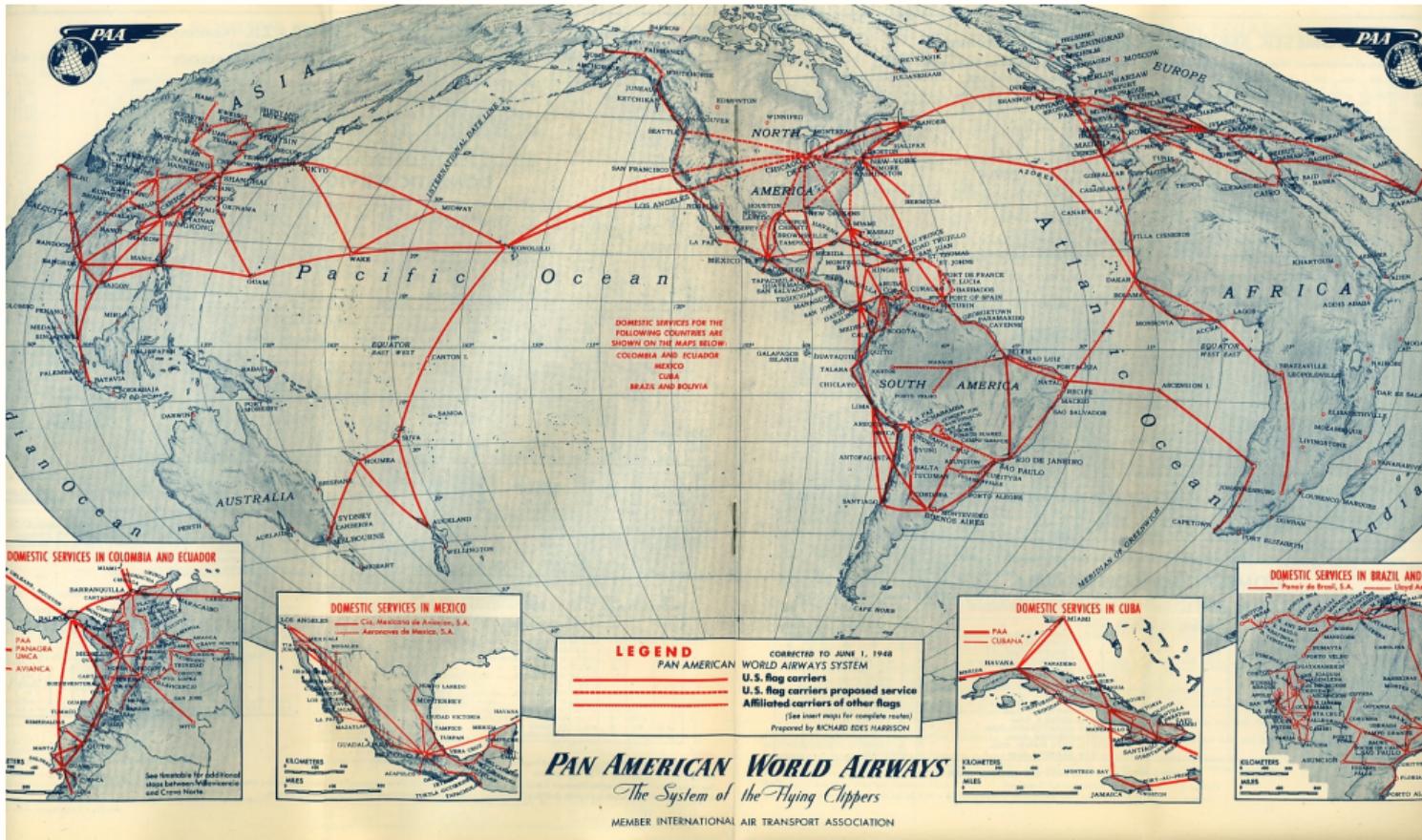


The Seven Bridges of Königsberg



The Seven Bridges of Königsberg—Revisualized

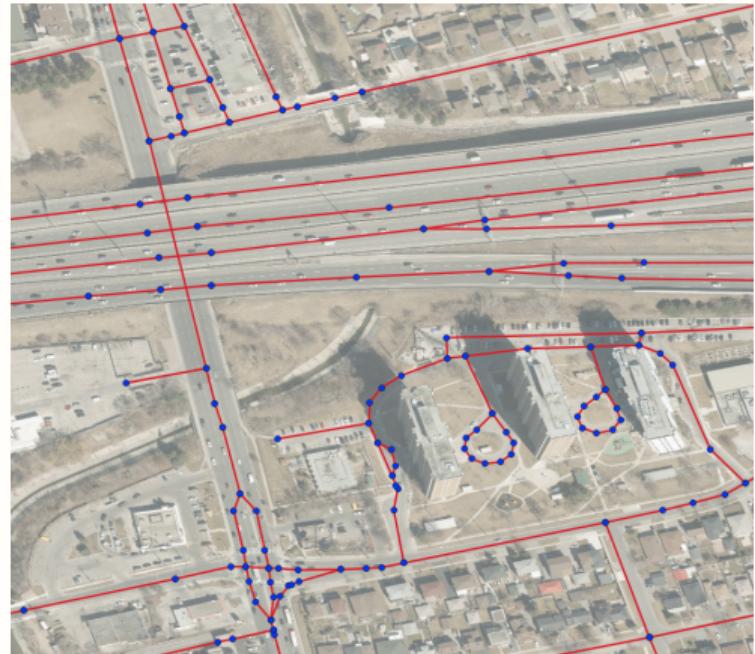
Source: <https://medium.com/basecs/konigsberg-seven-small-bridges-one-giant-graph-problem-2275d1670a12>



In transportation geography and planning, network data are used for measuring distances and travel times over *network* space.

These distances/times can be used for a range of analyses

Source: <https://www.openstreetmap.org>



Transportation network data sources:

Driving

- ▶ OpenStreetMap (free and detailed, depending on crowdsourced activity)
- ▶ Government sources (e.g. City of Toronto Centreline, Federal Road Network Files)
- ▶ Proprietary Networks (e.g. HERE, DMTI, Google Maps, etc.). Often used if needing travel times with congestion

Walking & Cycling

- ▶ OpenStreetMap (free and detailed, depending on crowdsourced activity)
- ▶ Various municipal gov't data sources

Transit

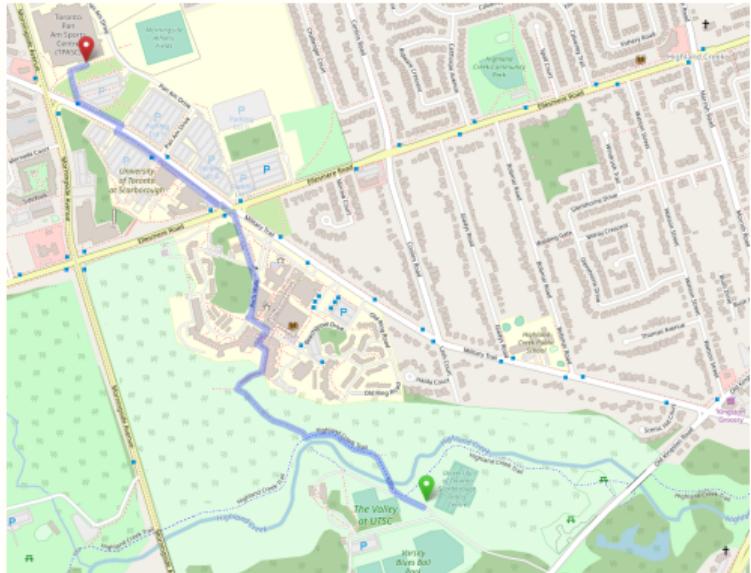
- ▶ GTFS (General Transit Feed Specification)

Network Distance

- ▶ The distance or travel time between two points, based on the *shortest-path* in a network graph.
- ▶ Included in many mapping applications and software (e.g. Google Maps, Uber, etc.)
- ▶ Different than straight-line (e.g. Euclidean) distance

Source: <https://www.openstreetmap.org>

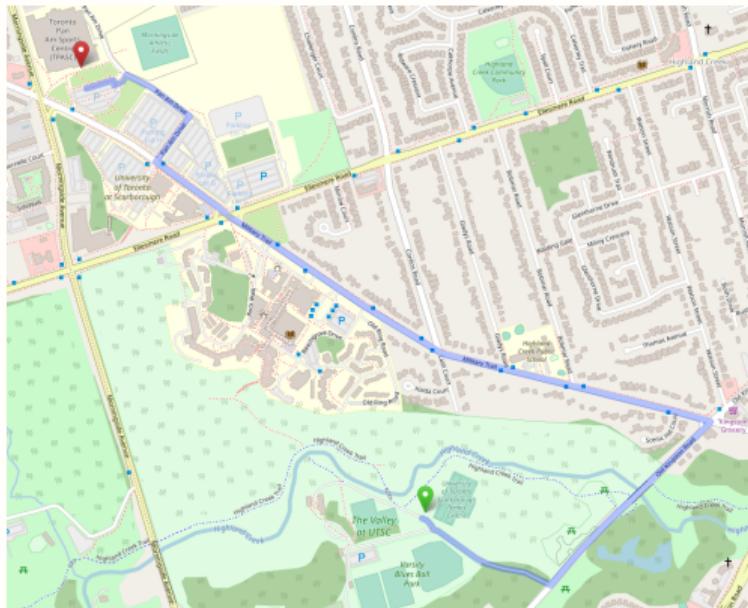
shortest-path by walking (22 min, 1.8 km)



shortest-path by bicycle (12 min, 2.5 km)

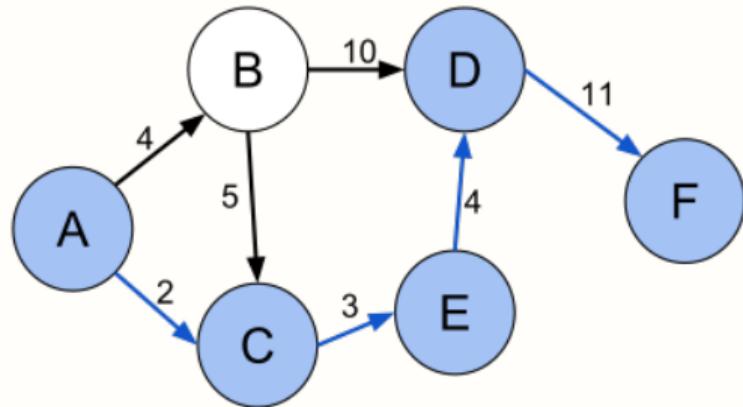


shortest-path by car (8 min, 3.0 km)

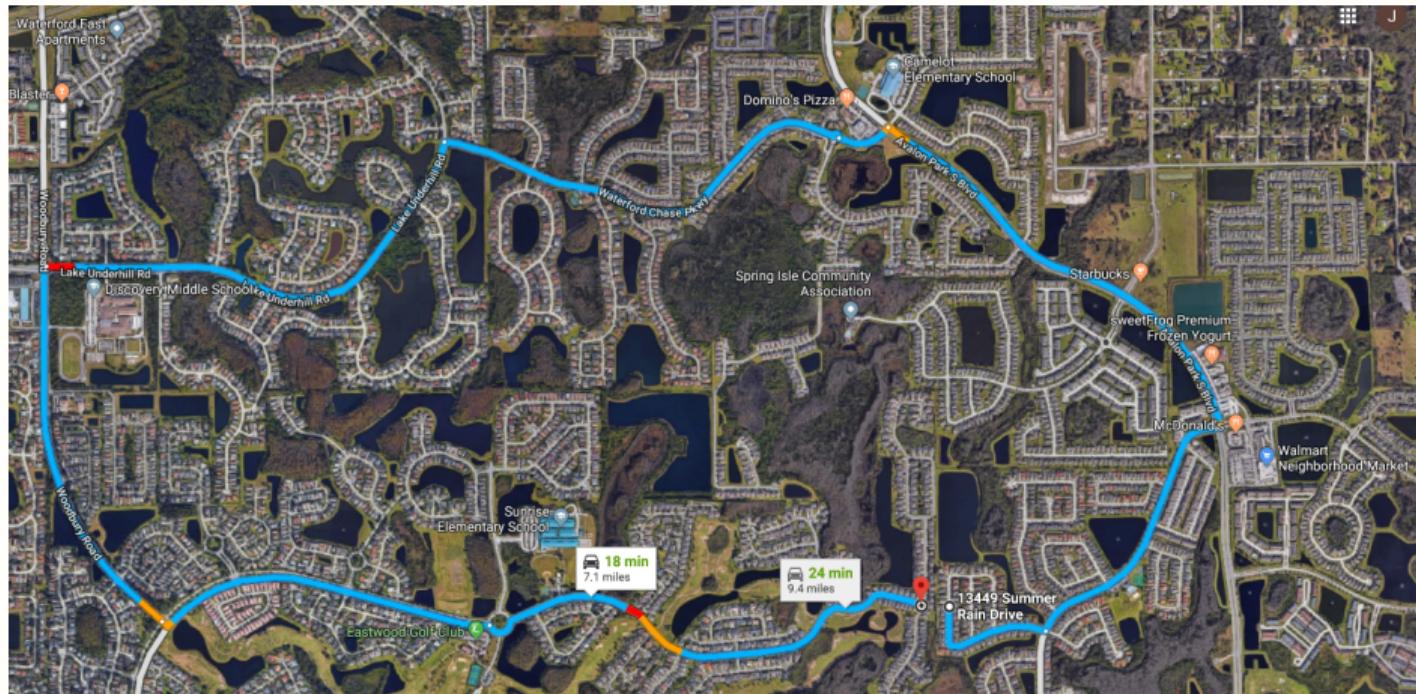


Shortest Path Analysis

- ▶ Finding the "shortest" path between A and B
- ▶ "shortest" can be in distance, time, other costs, or combination of costs
- ▶ Several different algorithms (e.g. Dijkstra)



https://en.wikipedia.org/wiki/Dijkstras_algorithm
https://en.wikipedia.org/wiki/Shortest_path_problem



<https://www.google.ca/maps/dir/28.5327099,-81.1608841/28.5326847,-81.1618508/@28.5363151,-81.1840563,6816m/data=!3m1!1e3!4m3!4m2!3e0!5i1>

13436 Summer Rain Dr, Orlando, FL 32822
14948 Golfway Blvd, Orlando, FL 32828, I

Add destination

Options

Send directions to your phone

via Golfway Blvd 2 hr 17 min

⚠ This route has restricted usage or private roads.

7.0 miles

Details

via S Alafaya Trail/S R 434 2 hr 34 min and Golfway Blvd 7.9 miles

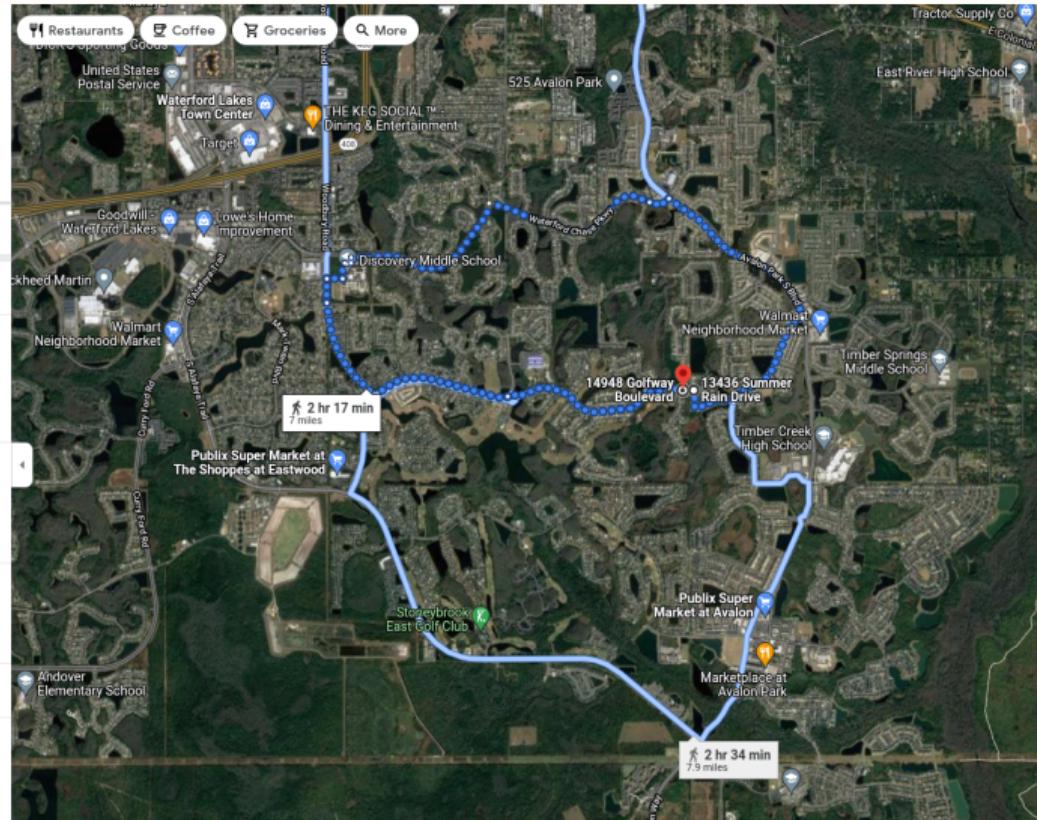
⚠ This route has restricted usage or private roads.

via Woodbury Road 3 hr 4 min

⚠ This route has restricted usage or private roads.

9.3 miles

All routes are mostly flat



<https://www.google.ca/maps/dir/28.5327099,-81.1608841/28.5326847,-81.1618508/@28.5363151,-81.1840563,6816m/data=!3m1!1e3!4m3!4m2!3e0!5i1>

Closest Facility Analysis - finding the nearest location(s) from a set of locations distributed over space

Often used in medical and emergency services.

- ▶ e.g. which fire station is closest to a fire
- ▶ e.g. what is the nearest emergency room

e.g. in Ottawa, is UofO or Carleton closer to where you live?



Location Allocation

- ▶ Procedures for determining the optimal location for one or more facilities that will service demand from a given set of points across space
- ▶ Often used in planning new locations of retail, public facilities, distribution centres, etc.
- ▶ Often use network distances + other data (e.g distributions of population)

Travelling Salesman

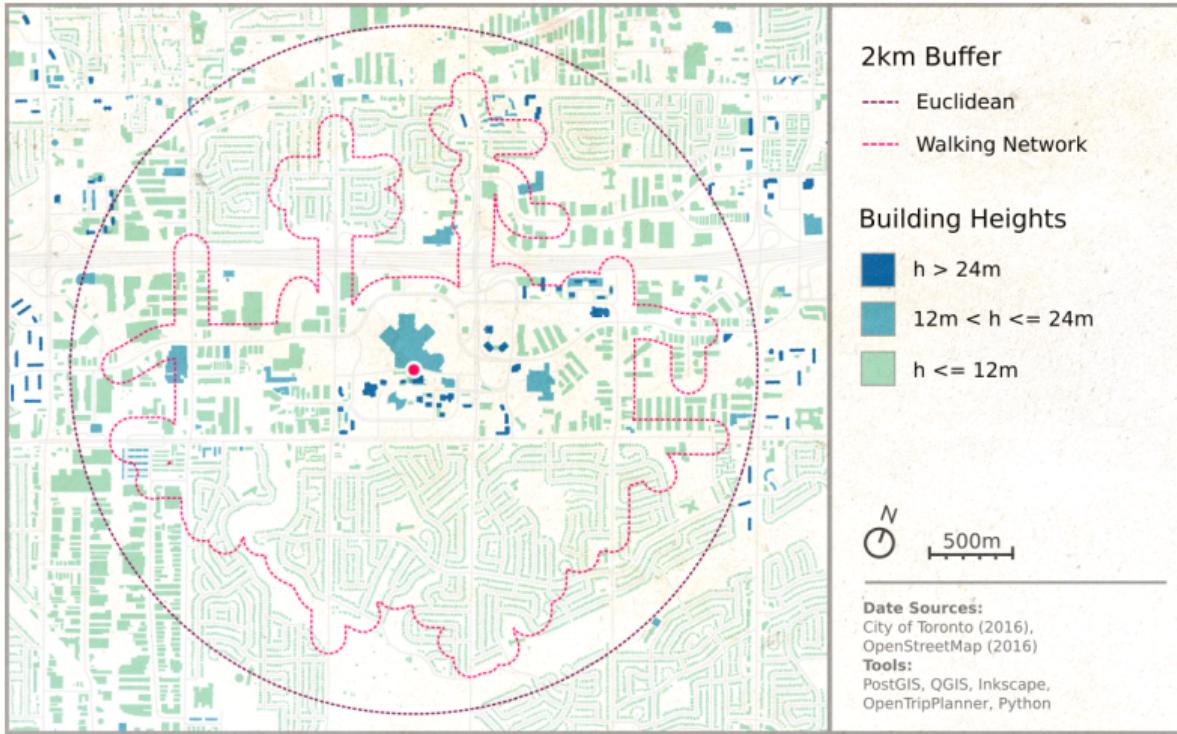
- ▶ Given a list of locations, and the (network) distances between each pair of locations, what is the shortest possible route that visits each location and returns to the origin point?
- ▶ e.g. what is the optimal route a salesman can take to visit potential clients in a region
- ▶ other applications include planning delivery routes or road trips

The optimal road trip visiting 50 cities in the USA



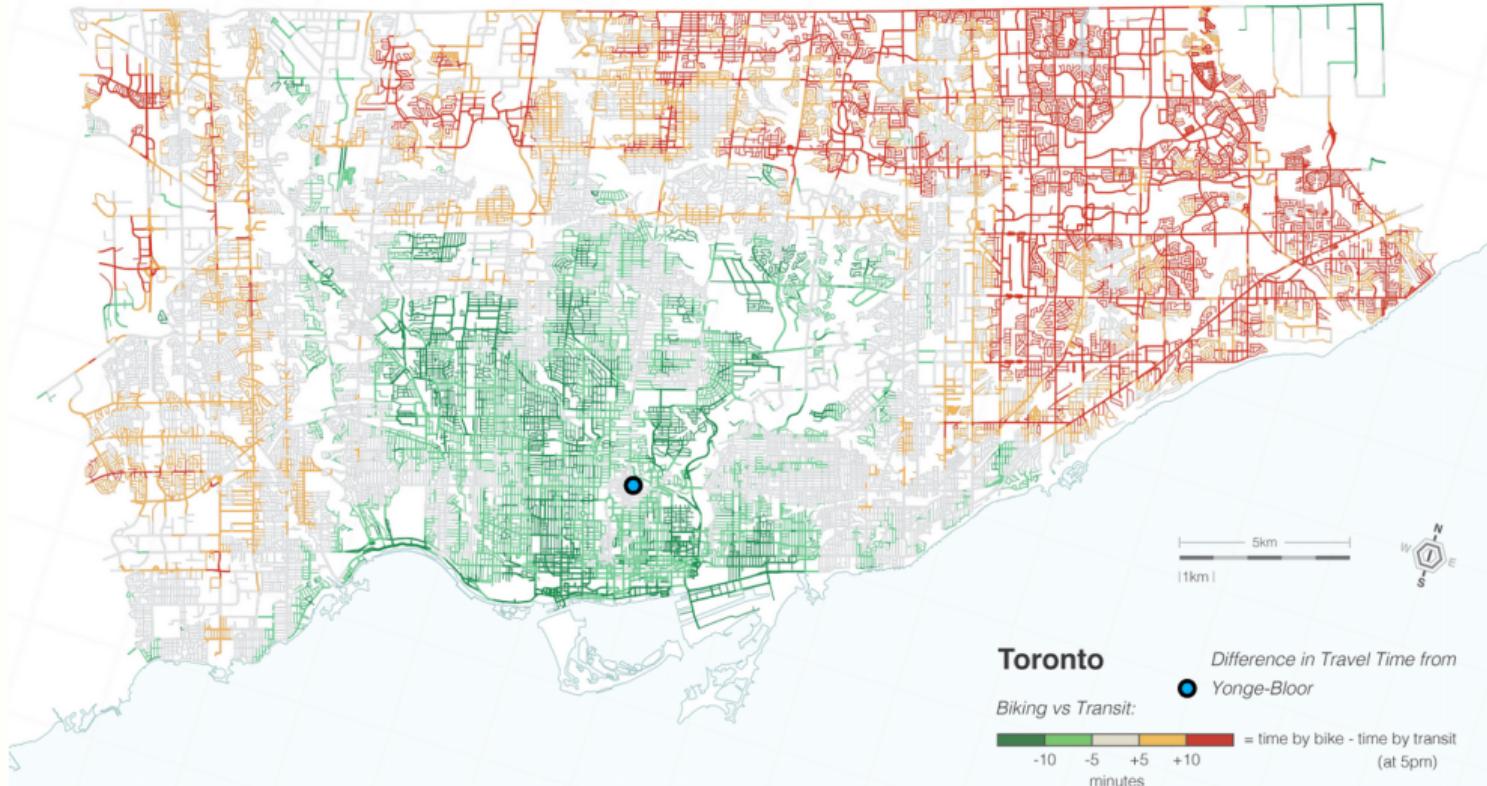
Source: Randy Olson (2015) <http://www.randalolson.com/2015/03/08/computing-the-optimal-road-trip-across-the-u-s/>

Isochrones (iso = equal, chrone = time) - A buffer based on *network* distances or travel times





Source: Galton, Francis. 1881. "On the Construction of Isochronic Passage-Charts." *Proceedings of the Royal Geographical Society and Monthly Record of Geography* 3: 657-658



Source: Allen, J. - *Using network segments in the visualization of urban isochrones* - Cartographica -
http://jamaps.github.io/docs/allen_2018_isochrones.pdf