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Accessibility to public transport

A global tool to evaluate accessibility

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About me



- [Miguel Ureña Pliego](#)
- MEng Civil Engineering at UPM (Spain)
- Visiting Student @ City Science (September 25 to March 2026)
- No drivers licence
(but licence to build roads)
- I like cats



What is accessibility?



- Good KPI for coverage
- Points of Interest (Pols)
- Distance / Time
- Very related to the 15-min-city
- CS-Gipuzkoa's 30-min-region



But not every PoI is equally attractive...

- Transit stop:
Subway vs bus
- Groceries:
Large chain vs small shop



Accessibility = PoI quality \times Distance



Accessibility to public transport

Accessibility = Pol quality × Distance



Accessibility to public transport

- Pols - Stops

$$\text{Accessibility} = \overbrace{\text{PoI quality}}^{\text{Public Transport quality}} \times \text{Distance}$$



Accessibility to public transport

- Pols - Stops
- Stop quality

$$\text{Accessibility} = \overbrace{\text{headway} \cdot \text{speed} \cdot \text{mode}}^{\text{Public Transport quality}} \times \text{Distance}$$



Accessibility to public transport

- Pols - Stops
- Stop quality
- Normalization [0, 1]

$$\underbrace{\text{Accessibility}}_{[0,1]} = \overbrace{\underbrace{\text{headway}}_{[0,1]} \cdot \underbrace{\text{speed}}_{[0,1]} \cdot \underbrace{\text{mode}}_{[0,1]}}^{\text{public transport quality}} \times \underbrace{\text{distance}}_{[0,1]}$$

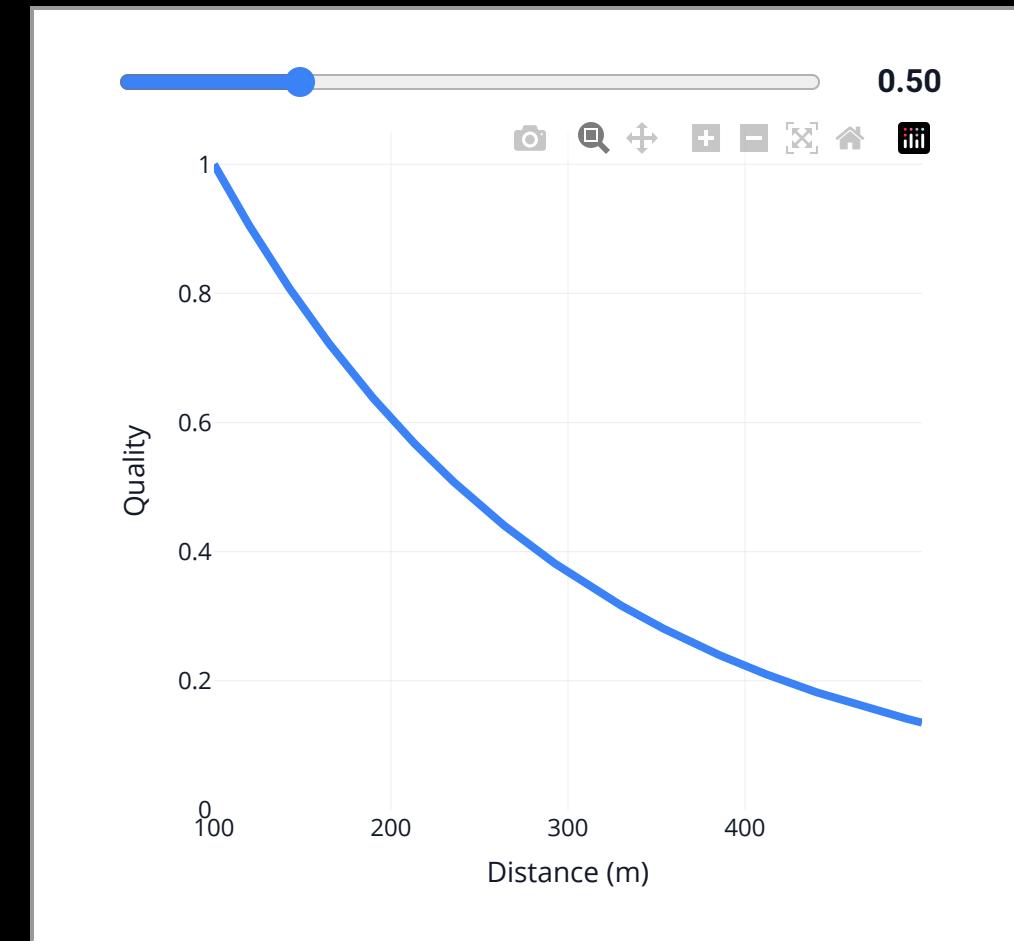


Quality functions

Distance → [0, 1]

Exponential decay function - Elasticity:

$$e = \frac{\% \text{ change in Demand} (\approx \text{ Quality})}{\% \text{ change in Distance}}$$



Accessibility to public transport

- Pols - Stops
- Stop quality



- Timetables

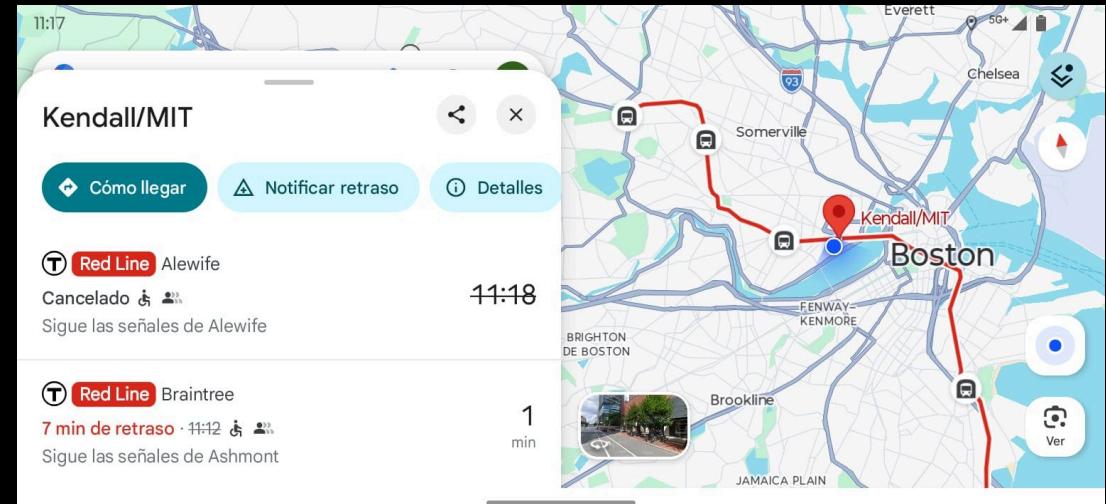
$$\text{Accessibility} = \underbrace{\text{headway} \cdot \text{speed} \cdot \text{mode}}_{\text{Public Transport quality}} \times \text{Distance}$$



Public transport timetables: GTFS

Global standard

- [Mobility Database API](#)
- [Transitland API](#)
- Local agencies (mandatory in the EU)



We all use it



Public transport timetables: GTFS

GTFS → stop location (grouping - parent_station)

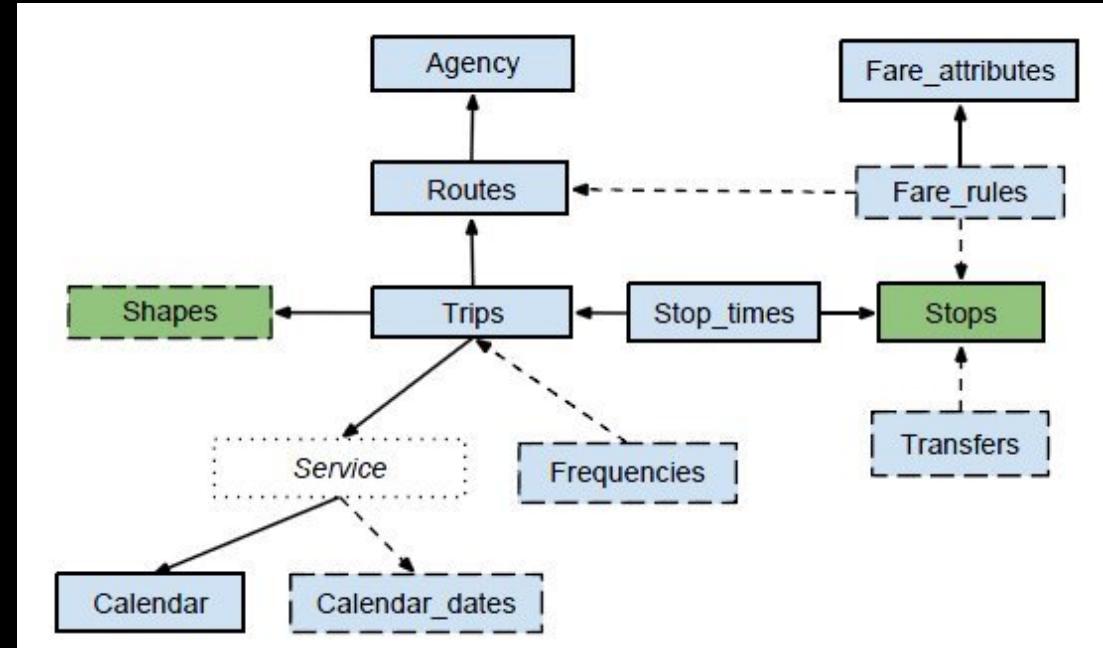
GTFS → headway, speed, mode



Not that easy...

✓ GTFS → stop location

😢 GTFS → headway, speed, mode



GTFS file structure

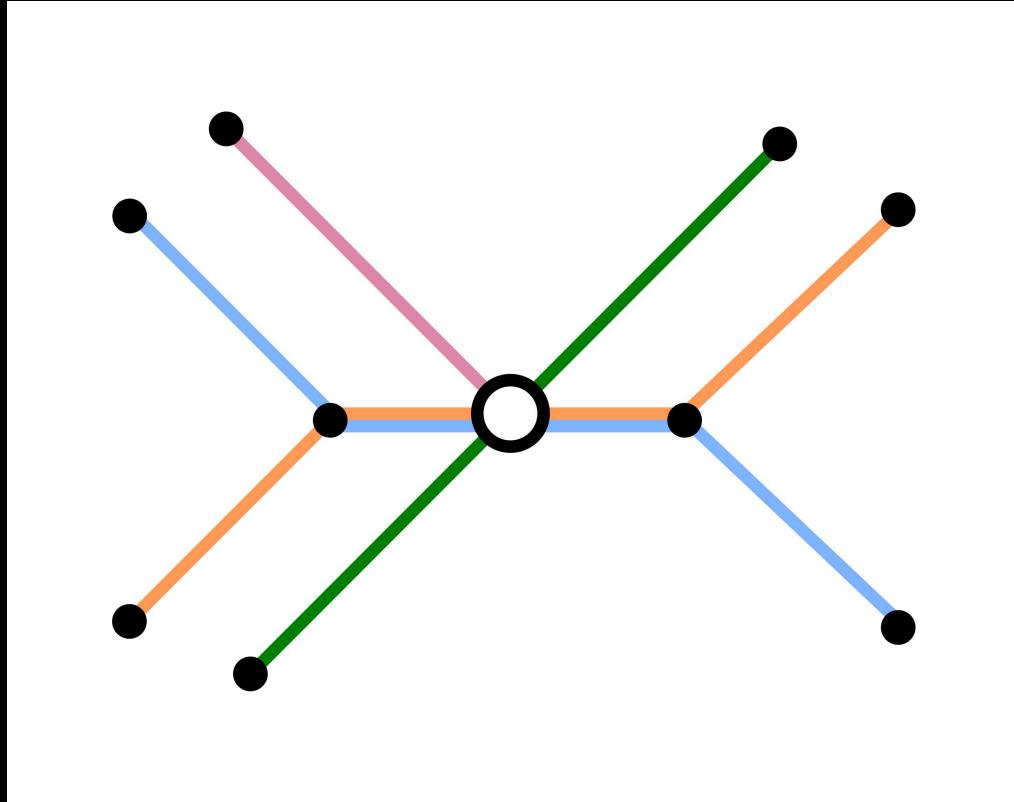


Stop quality

$$\text{Accessibility} = \overbrace{\text{headway}}^{\text{Public Transport quality}} \cdot \text{speed} \cdot \text{mode} \times \text{Distance}$$



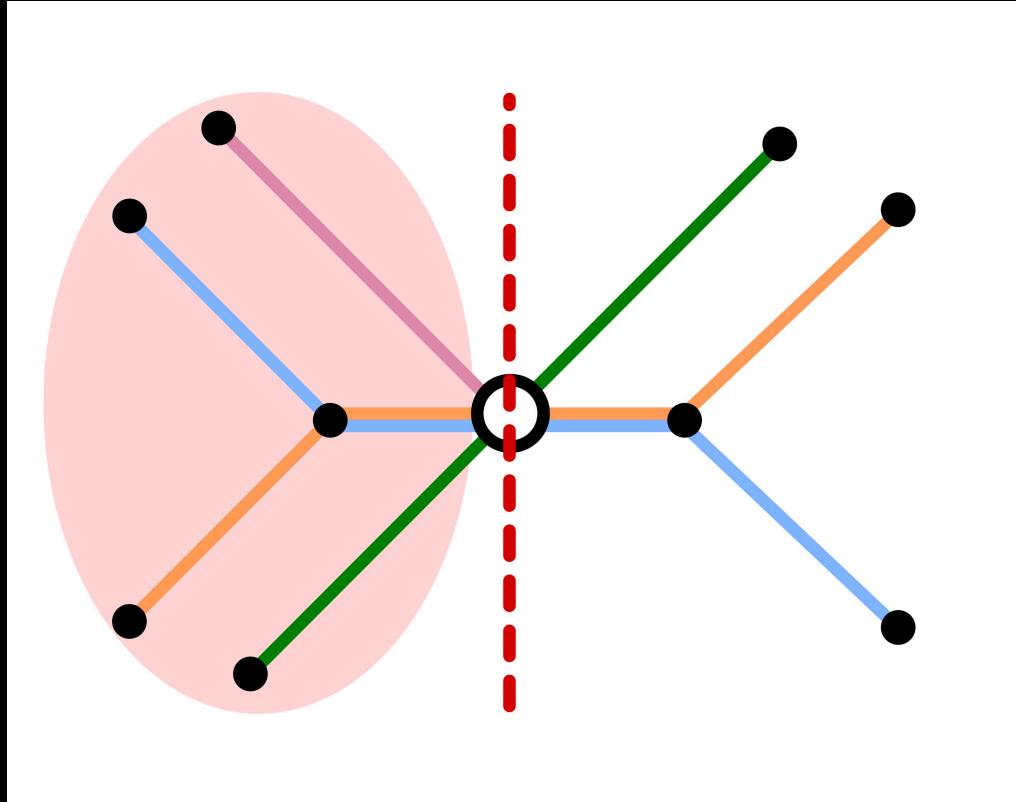
Headway



Contribution of multiple routes?



Headway

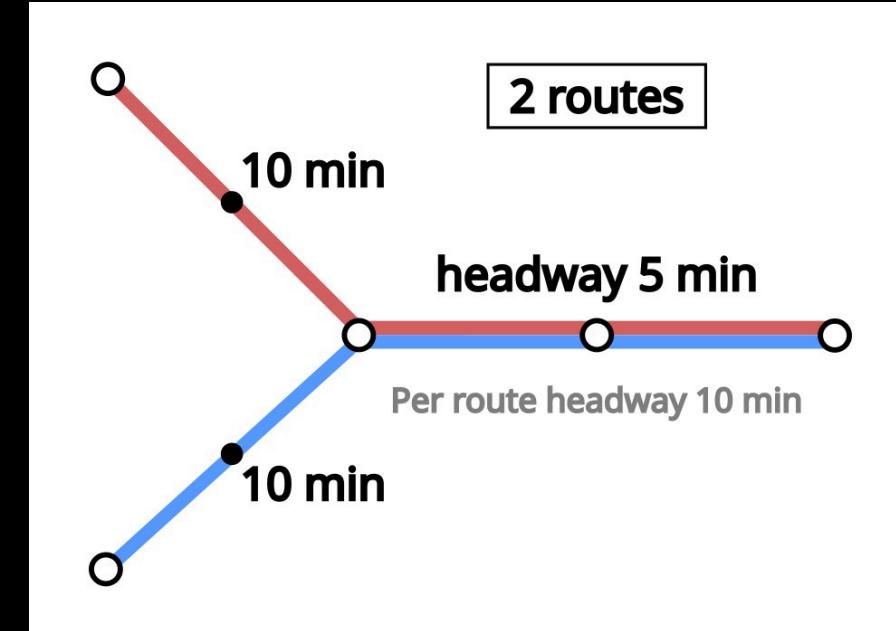
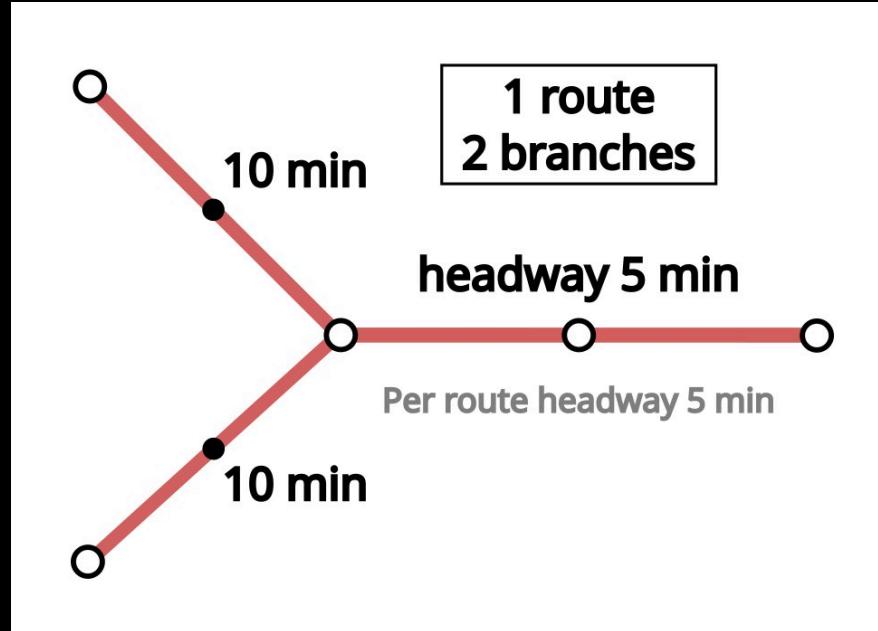


Harmonic mean

$$\text{HM} = 1 / \left[\text{mean} \left(\frac{1}{\text{headway}_i} \right) \right]$$



Headway: Trips and routes



The problem with the 'route' concept. Better use trips.



Headway

Elasticity:

Theoretical value:

0.5 (Mohring's Law)

Empirical:

< 30 min: $e = 0.3$ to 0.5

> 60 min: $e = 0.6$ to 1



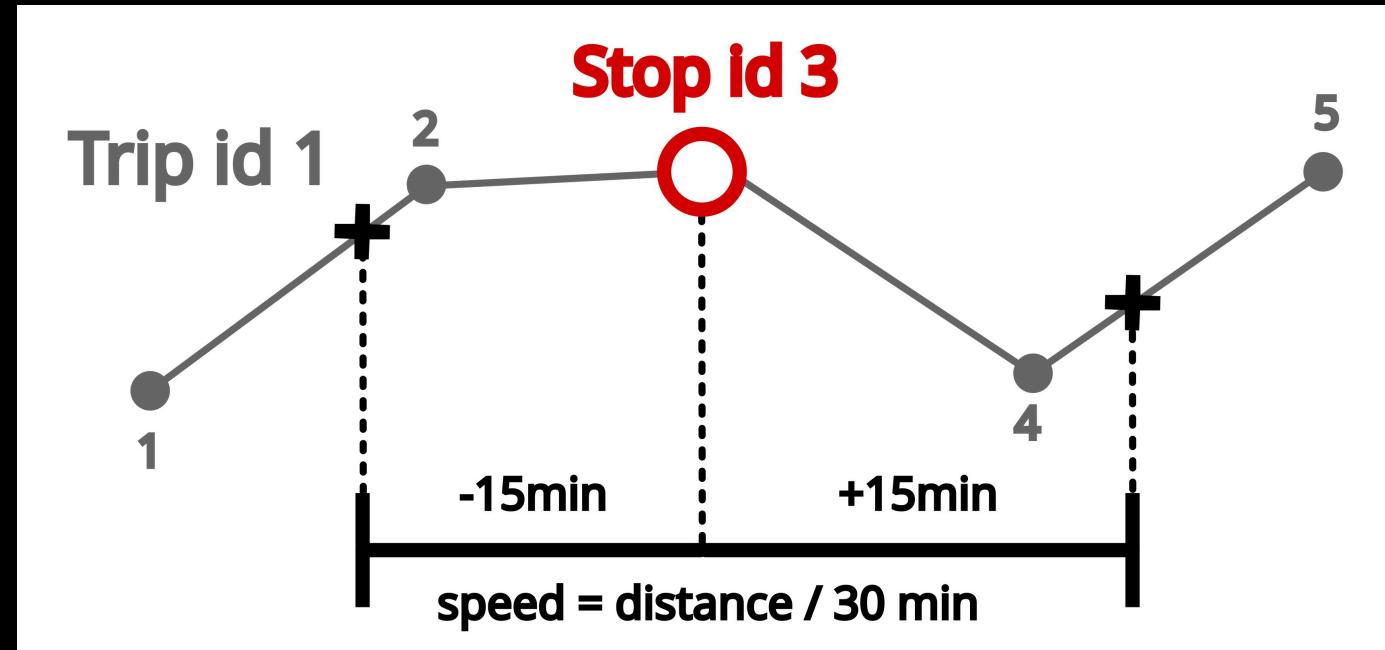
Stop quality

$$\text{Accessibility} = \underbrace{\text{headway} \cdot \text{speed} \cdot \text{mode}}_{\text{Public Transport quality}} \times \text{Distance}$$



Speed

- Per trip and stop
- Measured ± 15 minutes around each stop
- Elasticity: $e = 0.1 - 0.4$ (smaller than headway)



Speed

- Per trip and stop
- Measured ± 15 minutes around each stop
- Elasticity: $e = 0.1 - 0.4$ (smaller than headway)



 Leaflet | © OpenStreetMap contributors © CARTO



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Stop quality

$$\text{Accessibility} = \overbrace{\text{headway} \cdot \text{speed} \cdot \text{mode}}^{\text{Public Transport quality}} \times \text{Distance}$$



Mode

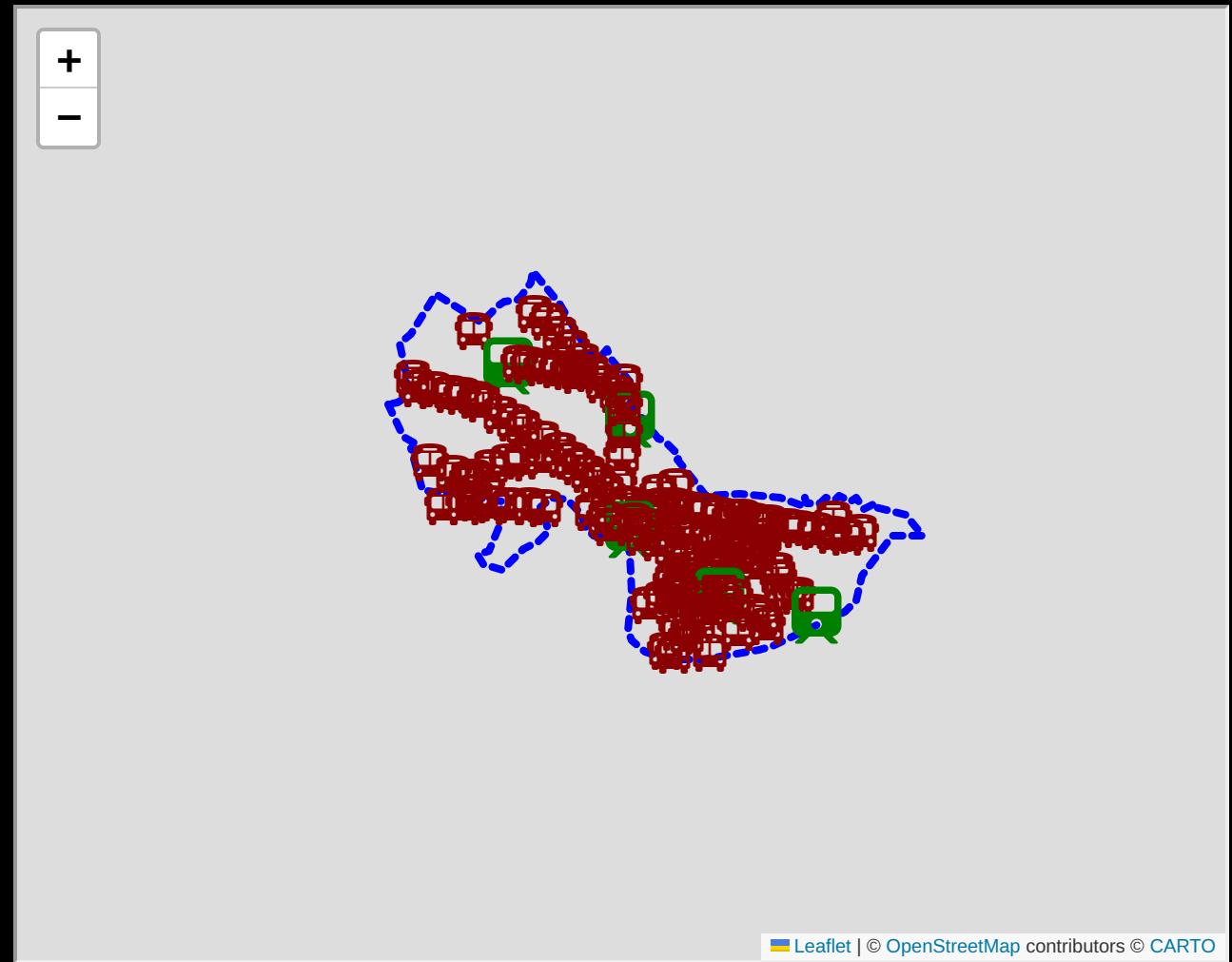
Values

- **Bus:** 0.5 – 0.9
- **LRT/BRT (tram):** 0.75 – 0.95
- **Subway/Train (rail):** 1

User comfort and capacity

route_type column in GTFS

No specific ID for BRT services



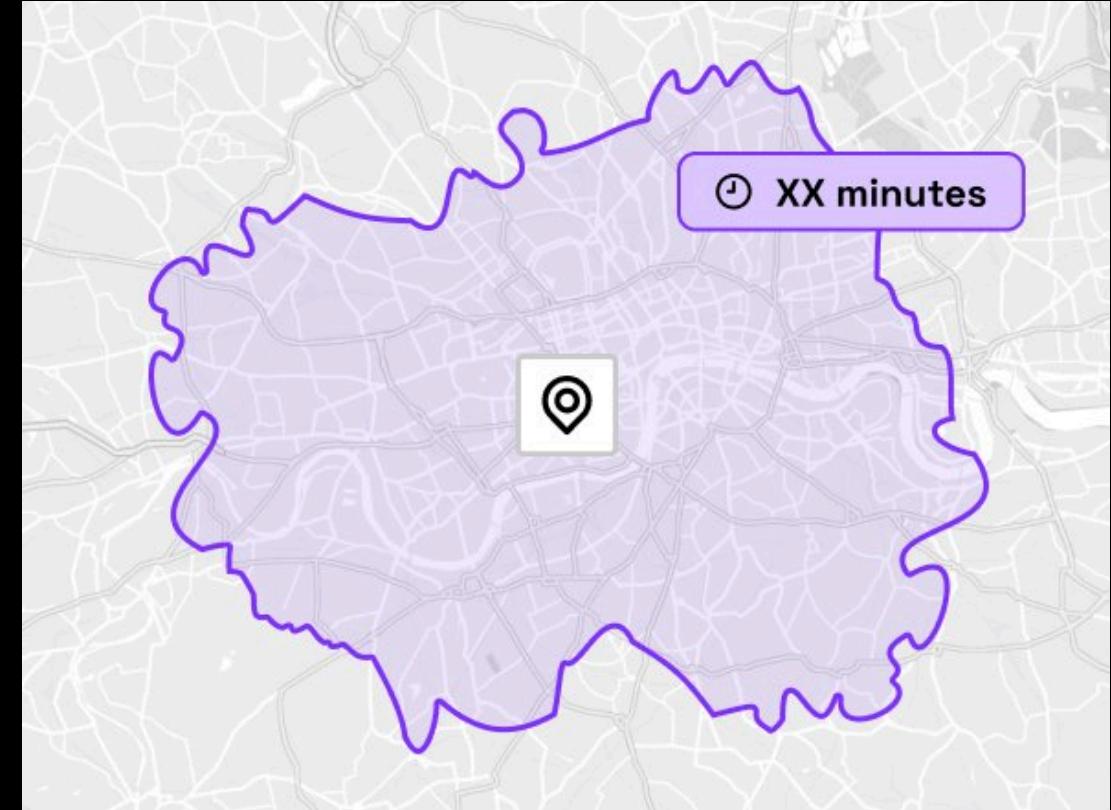
Accessibility

$$\text{Accessibility} = \overbrace{\text{headway} \cdot \text{speed} \cdot \text{mode}}^{\text{Public Transport quality}} \times \boxed{\text{Distance}}$$



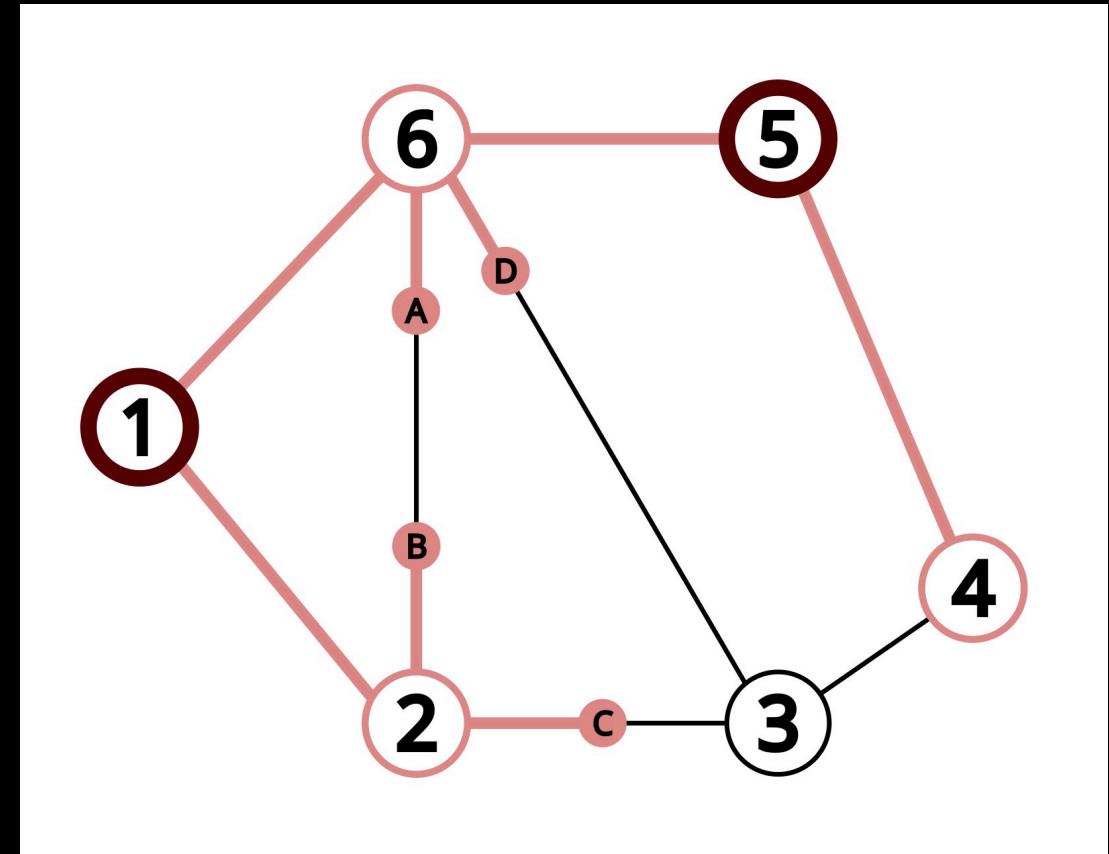
Distance/Time: Isochrones

- The area reachable in **X minutes** with a specific transport **mode** (public transport, walk, bike, car, etc.)
- Transport system graph
- For accessibility to public transport: walk isochrones
- Elasticity: $e = 0.1 - 0.4$ (smaller than headway)



A bit of graph theory

- Transport system graph
(source: OpenStreetMap streets)
- Geo-multi-source **Dijkstra**
(adds exact nodes at breakpoints)
- Discrete distances
- Discrete stop qualities



Discretization

1. Choose discrete accessibility grades



2. Stop quality and distance are discretized automatically



Lets see everything working



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Population/Census



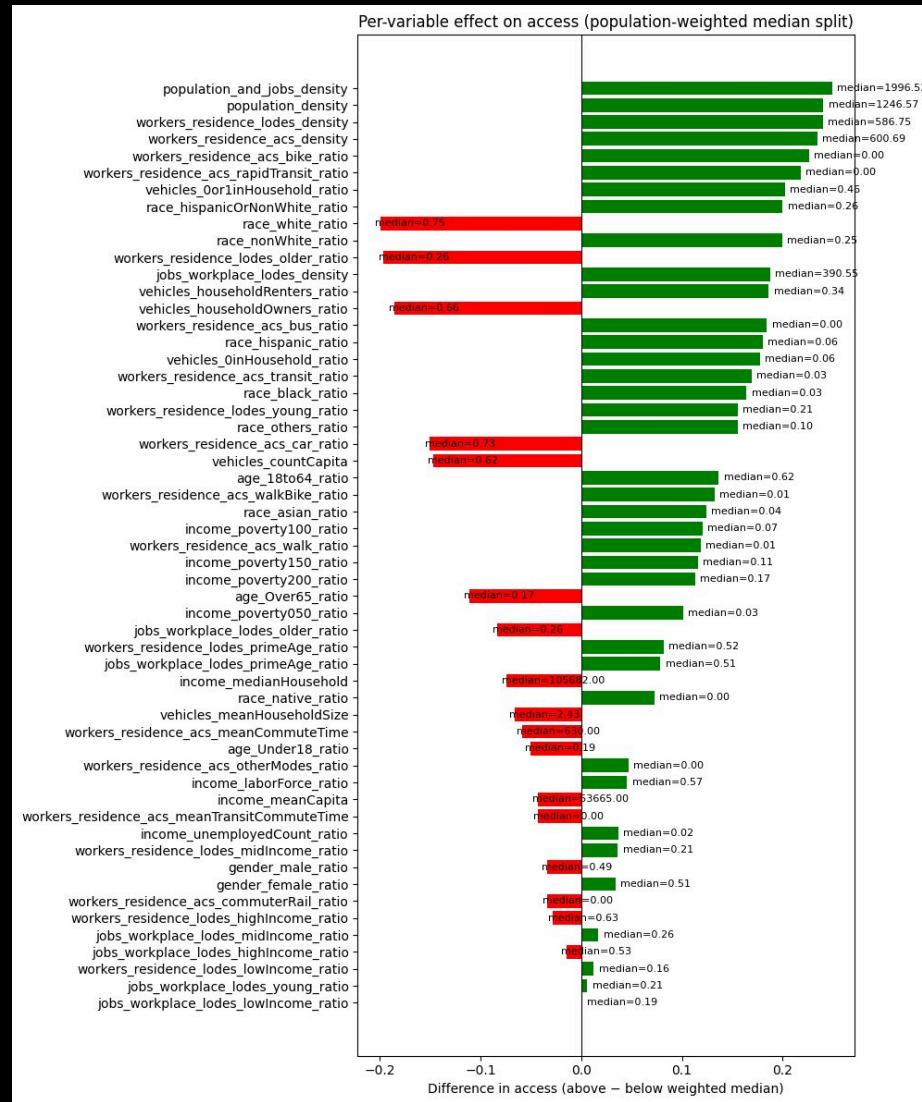
- Global source: [WorldPop](#)
- Census data: Individual countries



Equity

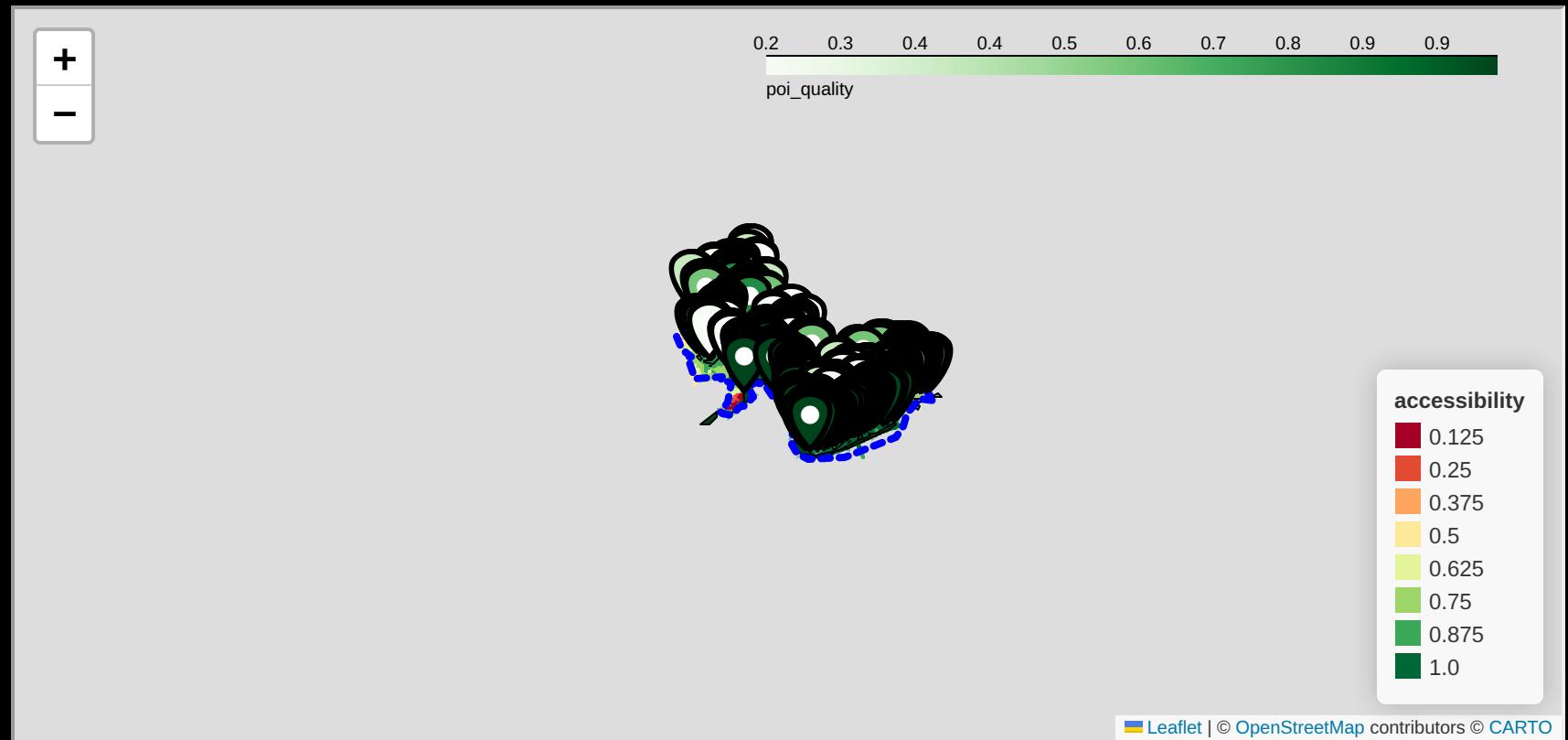
Most influential factors for Massachusetts

- Population density
- Car ownership
- Race
- But not income



This idea is flexible!

- Park quality by its **area**



Python packages

PyGTFSHandler

- Tutorial

Download GTFS and compute speed and headway

UrbanAccessAnalyzer

- Schools

Basic example and download of PolS from OpenStreetMap

- Parks

Simple tutorial introducing Pol quality

- Public Transport

Complete example of our accessibility to public transport indicator including isochrone computation and GTFS processing





Questions?

Thank you!

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