AVL-Based Transit Service Coverage and Accessibility Map

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Motivation

• San Francisco voters recently authorized $1.5 billion for transportation improvements by approving a bond measure this past November.

• With this success comes a mandate of sorts: SFMTA **must show the public that these improvements matter** to their everyday lives, or **risk losing support** for future transportation funding measures.

• Voters must see a **clear connection** between the funds they authorized and transit improvements.
Motivation

Transit improvements are a challenge to ‘sell’ to the public for several reasons:

- Common transit metrics are aggregate by nature
- People often recall their ‘worst trip’ when thinking about transit
- Improvements are usually incremental
- Proposals take some time to have an effect
- Reliability improvements are difficult to describe in a meaningful way

City staff recognized that more effective visualization tools may aid efforts to build support for transit improvements in San Francisco
Design Goals

From this motivation came some design goals for the project:

• Describe the service from the rider’s perspective

• Be an accurate representation of actual service

• As much as possible, provide personalized output so that the user sees the effects on individual riders

• Make the reasons behind engineering decisions more accessible to non-technical stakeholders

These design goals led to the choice of developing an interactive accessibility map as a tool for informing public opinion and aiding outreach efforts
Motivation

We also found this map can be used to evaluate existing service.

More generally, what is a transit agency selling?
Motivation

Our product is **access** to the rest of the city.

Muni customers pay for access with **travel time**, since the value of their time often exceeds what they pay as fare.
Motivation

Therefore a map like this represents how a person might evaluate Muni when making travel decisions.
The tool is hosted on a website and creates SVG images in the user’s browser using the d3.js library for JavaScript developed by Mike Bostock.

The files for the different scenarios are kept simple: just a series of .csv files with an intersection ID and an integer representing arrival time.

D3 handles the display and selection of these files, and no calculations are performed in the browser to save on processing time.
The calculations are performed on the back-end using Python 2.7 for Ubuntu Linux running on my Intel i7 (8-core) home computer and in the Amazon Web Services Cloud.

To reduce calculation times, the Amazon Web Services (AWS) Elastic Compute (EC2) platform is also used on a space-available basis, leveraging 96 computing cores to aid in simulating the millions of choices possible when navigating between the 8917 possible origins and destinations in the city.

Data structures and computations are aided by the pandas library for Python included in the Anaconda distribution.

Input data are obtained from reports generated for SFMTA from NextBus. These reports detail arrival times and departure times for each Muni vehicle on a given day.
To model travel time, I found values for each component of a trip:

- **Access Time**: Fixed value between two intersections. **Source**: Walking Model.
- **Wait Time**: Modeled as ½ the headway. **Source**: NextBus data.
- **In-Vehicle Time**: Used travel times between stops. **Source**: NextBus data.
- **Access Time**: Fixed value between two intersections. **Source**: Walking Model.
Access Time

It was first necessary to create a directed graph of the City for walking times:

• Using Python, I developed an algorithm that calculates the walking time to any point in the city given an origin.

• To reduce calculation time, origins and destinations are only intersections and endpoints of streets.

• The impedance on the graph is **time**, not distance.

• My walking time calculator has three speed settings and takes into account hills.

• Output an 8917 x 8917 matrix that can be referenced to find the walking time between any two points.

  Avg: 2.7 mph,
  Slow: 1.7 mph,
  Fast: 4.0 mph
To get the transit data, I first had to parse raw NextBus data and turn it into stop-by-stop statistics for each line:

- I collected weekday data from Jan – Mar 2014 for all Muni vehicles
- Overall, I processed 60,000 files into statistics for each line
- Collected median, 15th percentile, and 85th percentile headways and travel times

### Table of data

| Stop | ID | DIST_m | EARLY AM | MID AM | LATE AM | MID PM | LATE PM | EARLY E S E | MID E S E | LATE E S E | MID D S E | LATE D S E | MID M D S E | LATE M D S E | MIDDAY | HS MID M D S E | HS EARLY M D S E | HS MID M D S E | HS LATE M D S E | HS MID M D S E |
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* Parsing

To get the transit data, I first had to parse raw NextBus data and turn it into stop-by-stop statistics for each line:

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Transit Algorithm - Generalized

- Each line was modeled as a separate directed graph. To access each new graph, the ‘sample traveler’ must pay a time penalty.

  Set a time limit and an origin

  Find all walkable destinations from origin inside time limit

  Lookup which of these destinations are stops

  Lookup all lines available from each stop

  Find the stops that can be reached in the remaining time

  List of destinations and times

  Apply wait time

  Transfers

- The list of destinations only keeps the lowest time
- The fastest route is calculated, but the route information is not saved (too much data to store)
- Only one transfer is calculated and transfers are assumed not to be coordinated
Interactive Transit Map of San Francisco
prerelease alpha 0.8.2 Dan Howard | UC Berkeley

Average Travel Times
- 10 min
- 20 min
- 30 min
- 40 min
- 50 min
- 60 min
- 70 min
- 80 min

Key:
- BART Station
- Muni Light Rail Stop
- Shops/Businesses
- Parks

Set Maximum Travel Time: 30 minutes

Data courtesy of SFMTA
Interactive Transit Service Map of San Francisco

beta 3.0 Dan Howard | UC Berkeley

What you should usually be able to reach in 30 min from

Market St & Steuart St

Set Maximum Travel Time: 30 minutes

Data courtesy of SFMTA
What you should usually be able to reach in 30 min from

Avg Travel Times
4PM-7PM
15 min
30 min
45 min
60 min
75 min
100 min

Location of Pointer

ocf.berkeley.edu/djhoward/transitmap/transit.html
Demonstration

The farthest you might be able to get in 30 min on a bad transit day from Market St & Steuart St.

Max Travel Times
4PM-7PM
- 15 min
- 30 min
- 45 min
- 60 min
- 75 min
- 100 min

ocf.berkeley.edu/djhoward/transitmap/transit.html
What you should usually be able to reach in 30 min from Market St & Steuart St

Avg Travel Times
4PM-7PM
- 15 min
- 30 min
- 45 min
- 60 min
- 75 min
- 100 min

Location of Pointer

ocf.berkeley.edu/djhoward/transitmap/transit.html
What you should usually be able to reach in 45 min from Market St & Steuart St

Avg Travel Times
4PM-7PM
- 15 min
- 30 min
- 45 min
- 60 min
- 75 min
- 100 min

Location of Pointer

csf.berkeley.edu/djhoward/transitmap/transit.html
Demonstration ocf.berkeley.edu/djhoward/transitmap/transit.html
What you should usually be able to reach in 45 min from Market St & Steuart St

Avg Travel Times
4P-M 7PM
15 min
30 min
45 min
60 min
75 min
100 min

San Francisco Bay
Golden Gate Park
Presidio
Geary Blvd
Ocean Ave
Pacific Ocean

Location of Pointer

ocf.berkeley.edu/djhoward/transitmap/transit.html
In ‘beta’ version (3.0)

- Calculates median, best and worst case transit coverage at 5 times of day
- Assumes user walks at average speed and is willing to walk 10 minutes max
- Estimates travel uncertainty (difference between median and worst case)
- Calculates the number of jobs accessible from an origin point
- Incorporates 3:1 compression on server
- Effects of Central Subway project forecasted

Future add-ons will include:

- Modelling people with limited ability to access stops (using walking speed of 1.8 mph)
- Modelling people unwilling to walk more than 5 minutes
- Model showing the effects of incremental transit improvements
Planning Applications

The tool can display the impact of service changes or new capital improvements on the accessibility or mobility for trips originating at every point of the city.

These include:
New routes
New route alignments
Headway changes
Travel time improvements
Stop addition, removal, or relocation
The tool can display gaps in transit coverage for evaluation by planners.

Travel Time:
35 min

Gap:
Potrero Hill

Origin: SOMA
Planning Applications

The tool can be integrated with an amenities database to show a location’s access to various services by foot and by transit.

Interactive Transit Service Map of San Francisco
beta 3.0 Dan Howard | UC Berkeley

What you should usually be able to reach in 30 min from

Avg Travel Times
- 15 min
- 30 min
- 45 min
- 60 min
- 75 min
- 100 min

jobs 122,148
Interactive Transit Service Map of San Francisco

What you should usually be able to reach in 30 min from

Jobs 122,148

Avg Travel Times
- 7AM-9AM
- 15 min
- 30 min
- 45 min
- 60 min
- 75 min
- 100 min

Location of Pointer

Pacific Ocean

San Francisco Bay

Golden Gate Park

Presidio

San Francisco Bay

Lombard St

Divisadero St

Geary Blvd

Ocean Ave

Judah St
Interactive Transit Service Map of San Francisco

What you should usually be able to reach in 30 min from

Jobs 280,586
This tool has been adapted to show accessibility of different points in the city to a range of amenities, like jobs.
The technology behind the tool can be used to create hypothetical trip diaries based on a person’s origin, destination, and departure time. A diary could represent a single day in history or it could be a composite generated from a sample of days.

**Columbus & Union -> South Van Ness & Market – 8:05 AM**

1 3 8 2 3 3 1 min = 22 min

**Columbus & Union -> South Van Ness & Market – 8:10 AM**

28 min = 1 7 10 2 4 3 1
The tool can also evolve into a public information tool that gives a percent chance of making the bus, or expresses bus arrivals as a range instead of a single number.
Questions?

Contact me for more information!

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ocf.berkeley.edu/djhoward

Try the tool here!
ocf.berkeley.edu/djhoward/transitmap/transit.html