

How to Build a Large Scale Data Visualization

Mike Barry - Twitter
Brian Card - ViaSat

Project History In Brief

Project History In Brief

February 2014 - Collected Data

March - June - Built Project

June - Published

January 2015 - NEASIST

Press

- “Beautiful Work!” –Mike Bostock
- “Insanely Awesome” – Roberto Scalese of Boston.com
- “Beautifully crafted exploration... one of those projects you simply dream of having in your portfolio” – Andy Kirk of Visualizing Data
- Mentions by Edward Tufte, The Guardian, CNN Money, Flowing Data, FiveThirtyEight, The Atlantic and others

Total Cost: \$0

Total Cost: \$0

Project Management

data Visualization Tools

Website Publishing Code Hosting

Presentation Tools

How Did We Do It?

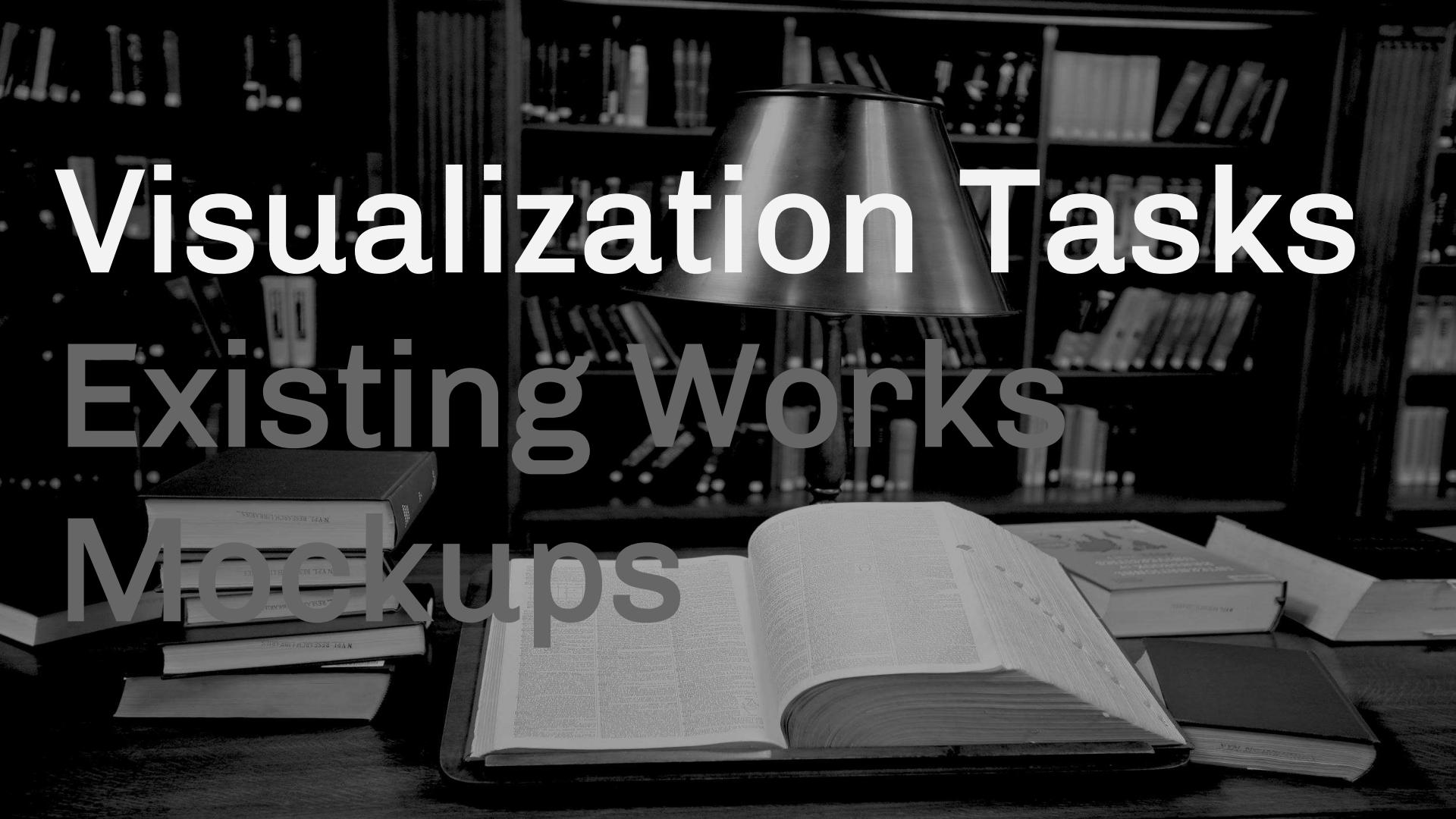
Research



Visualization Tasks Existing Works Mockups



Visualization Tasks Existing Works Mockups



A black and white photograph of a subway platform. A train is stopped on the left, its side featuring a large, stylized letter 'T' logo. The platform floor is made of grey tiles. In the background, a person walks away from the camera towards a bright exit. The station has a modern concrete structure with multiple levels visible above the platform.

What's Your Goal?

A black and white photograph of a subway platform. A train car is visible on the left, and another train car is on the right, with the words "QUINCY ADAMS" partially visible on its side. The platform floor is made of large tiles. In the background, there is a multi-story concrete parking garage or building with several levels and windows.

To Visualize The
Train System!



To VTA
Train

The
System!

QUINCY ADAMS



What's Important To People

- Congestion and Delay
- Snowstorms
- My Commute



Have Ideas To Throw Away





Organize Everything!



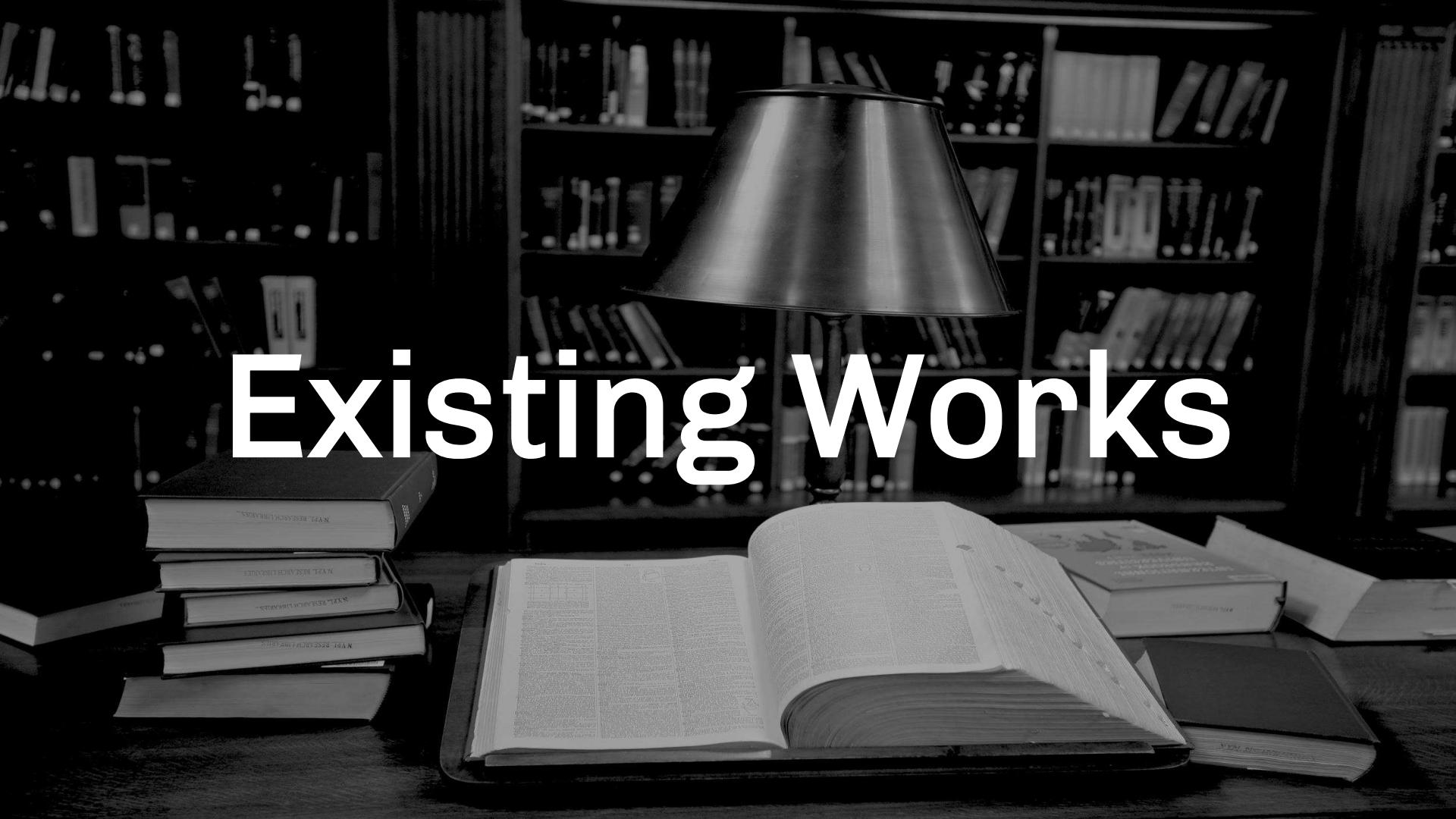
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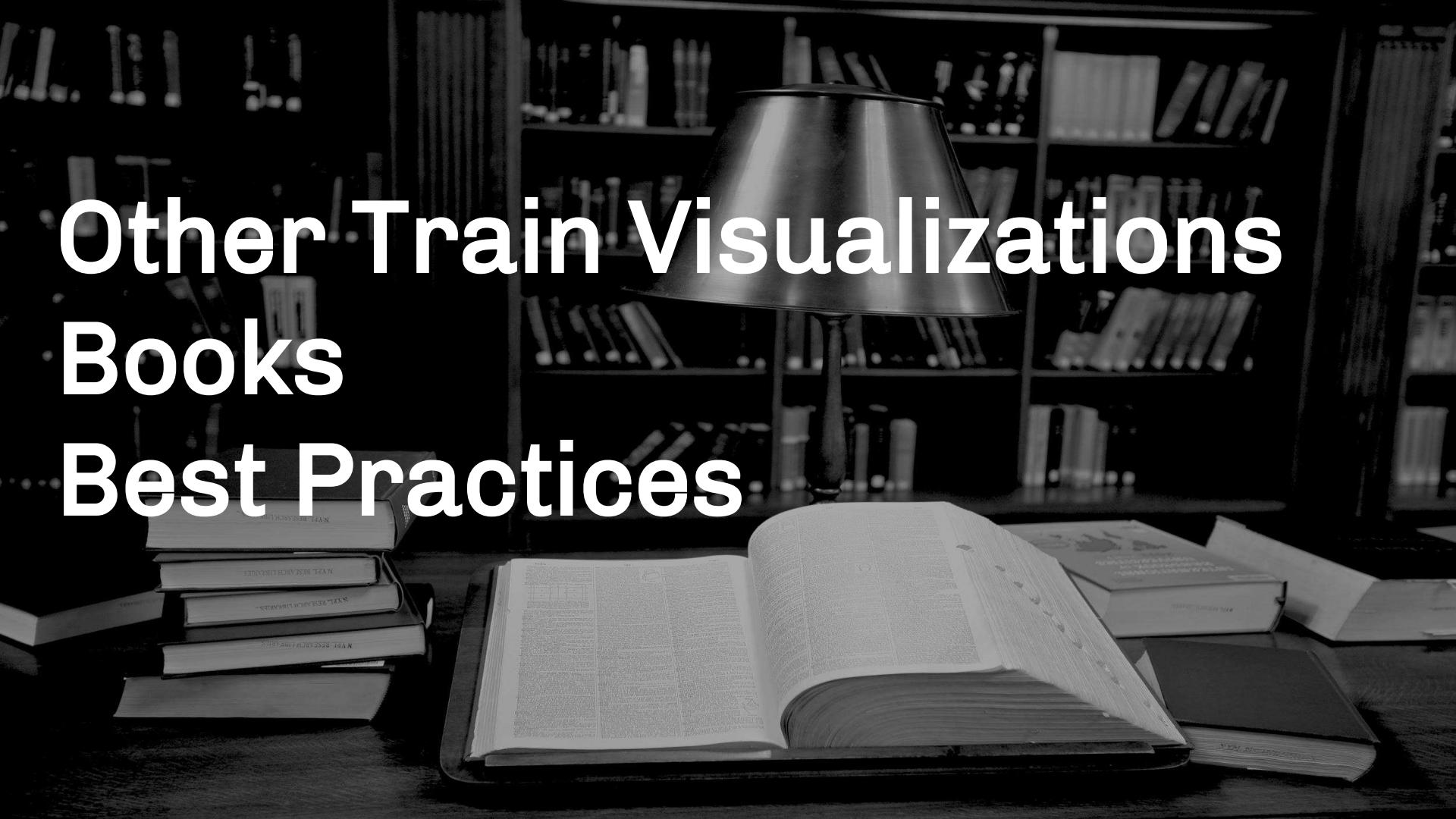
Google docs



Trello

Existing Works





Other Train Visualizations

Books

Best Practices

Mockups

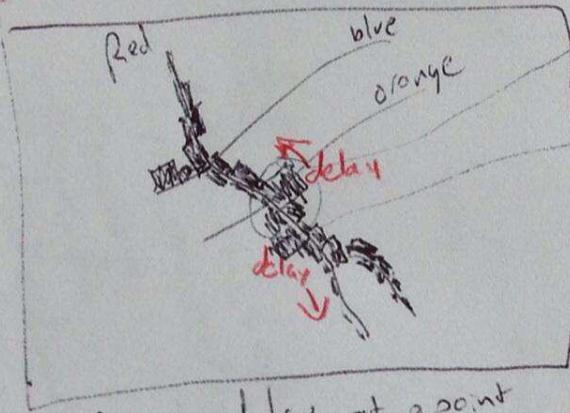


Pen + Phone + Computer

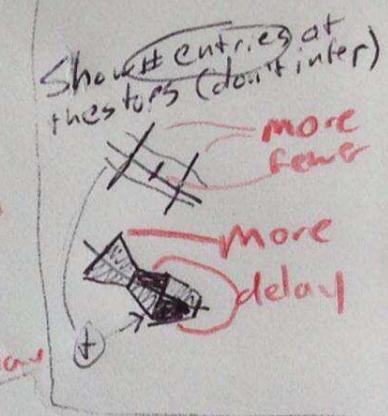
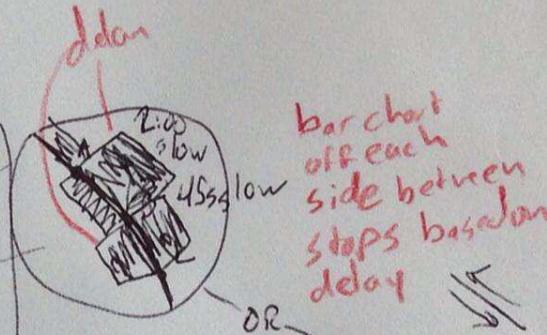
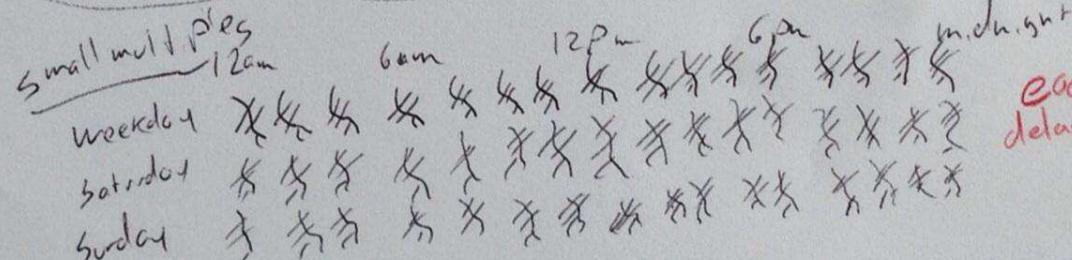


Overview
at one point
in time

Use real locations
so shape is familiar



Use these as
building blocks
for:



but this doesn't
let us use red/orange/
blue car lines

each one shows
delay at that time

Data Collection And Prototypes

MBTA Web API

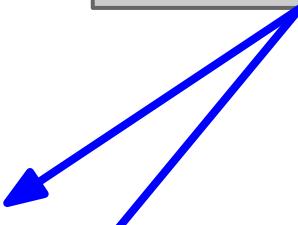
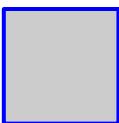
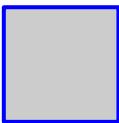
MBTA

Mike

Brian

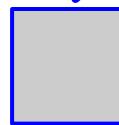
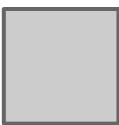
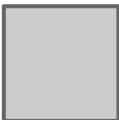


Mike
Brian



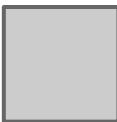
Mike
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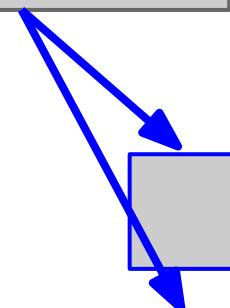
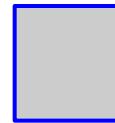
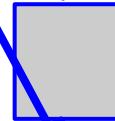
Mike
Brian

MBTA



Mike
Brian

MBTA



MBTA

Mike

Brian

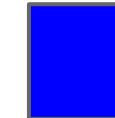
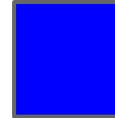


MBTA

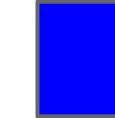
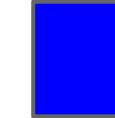
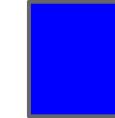
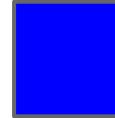
Mike

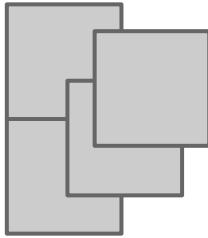


Brian



Merged



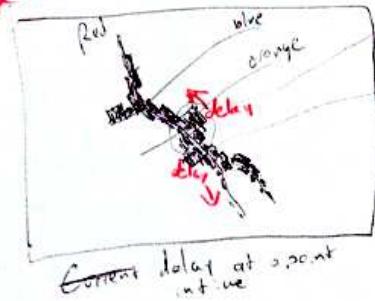


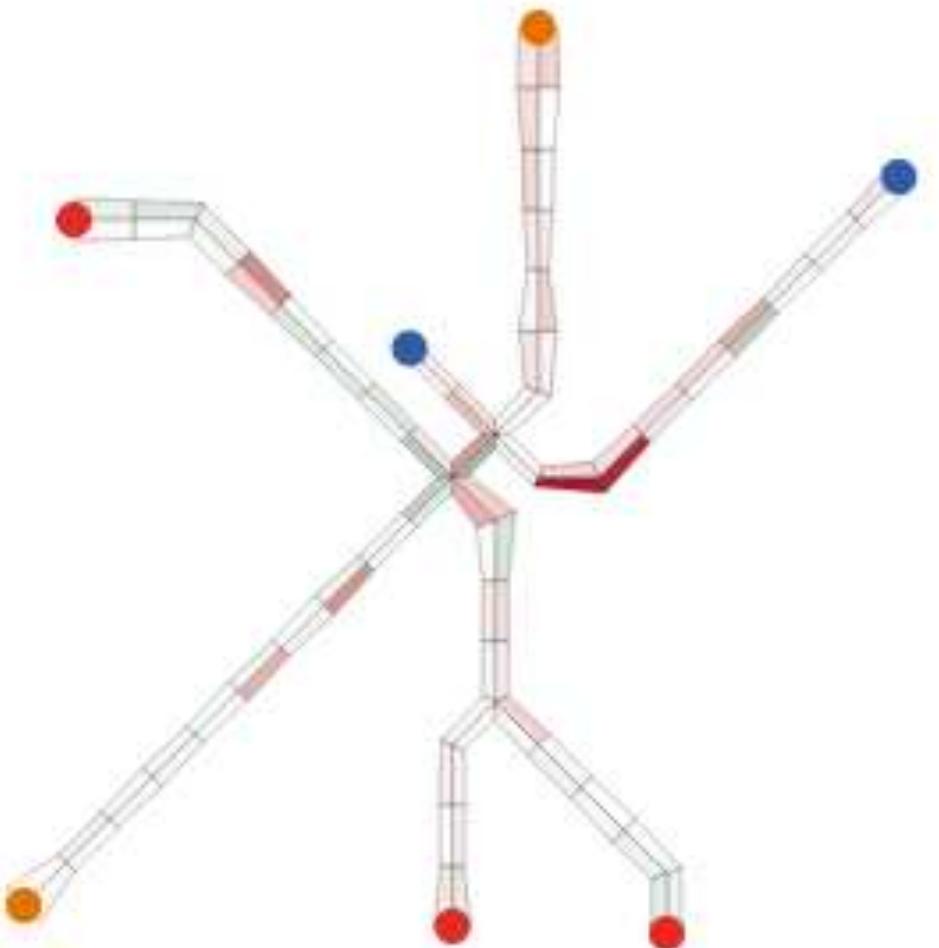
?



Over-view
at one point
in time

Use real locations
so shape is familiar





7:32 am on Mon Feb 3

Mon

Feb 3

Tue

Feb 4

Wed

Feb 5

Thu

Feb 6

Fri

Feb 7

Sat

Feb 8

Sun

Feb 9

1AM

3AM

5AM

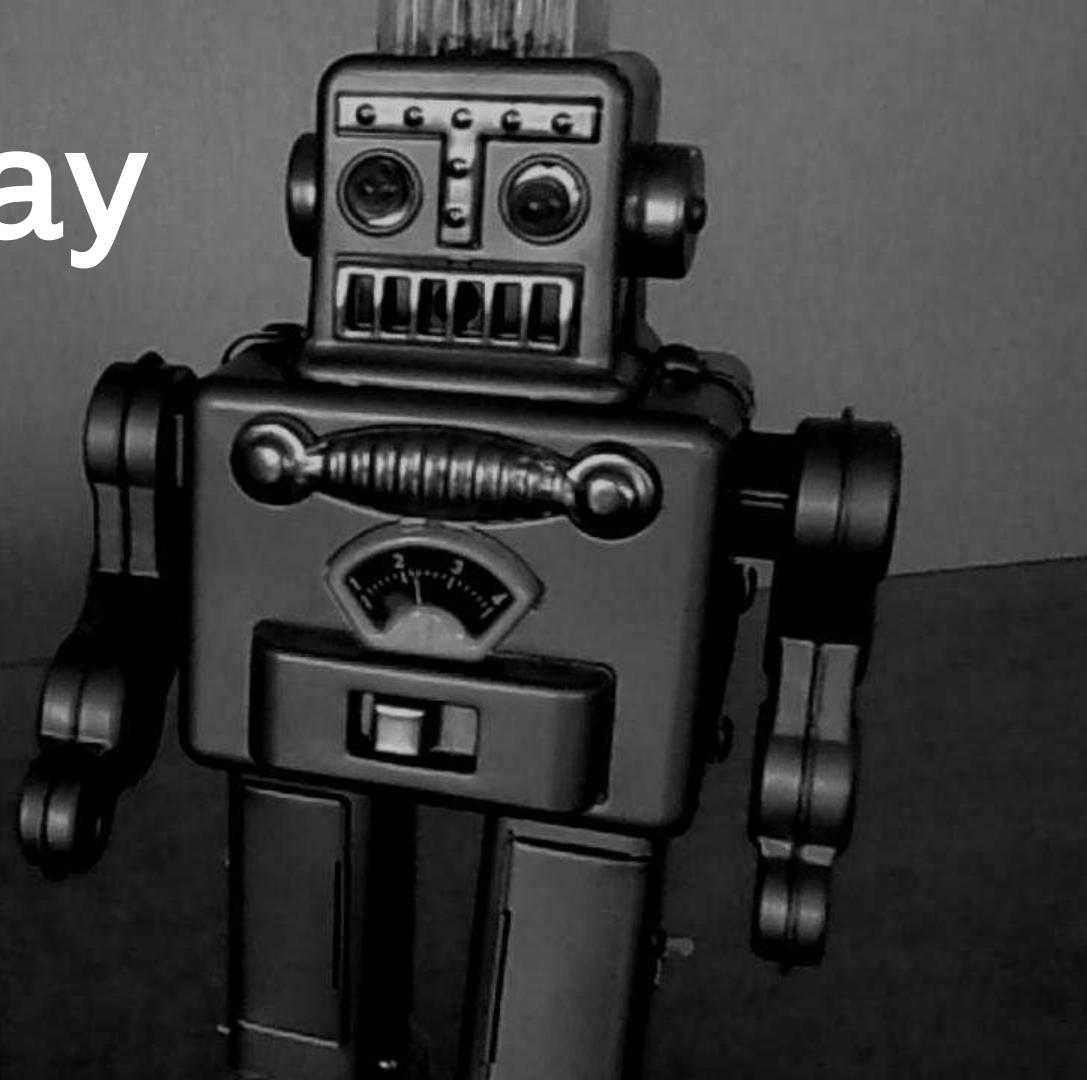
7AM

9AM

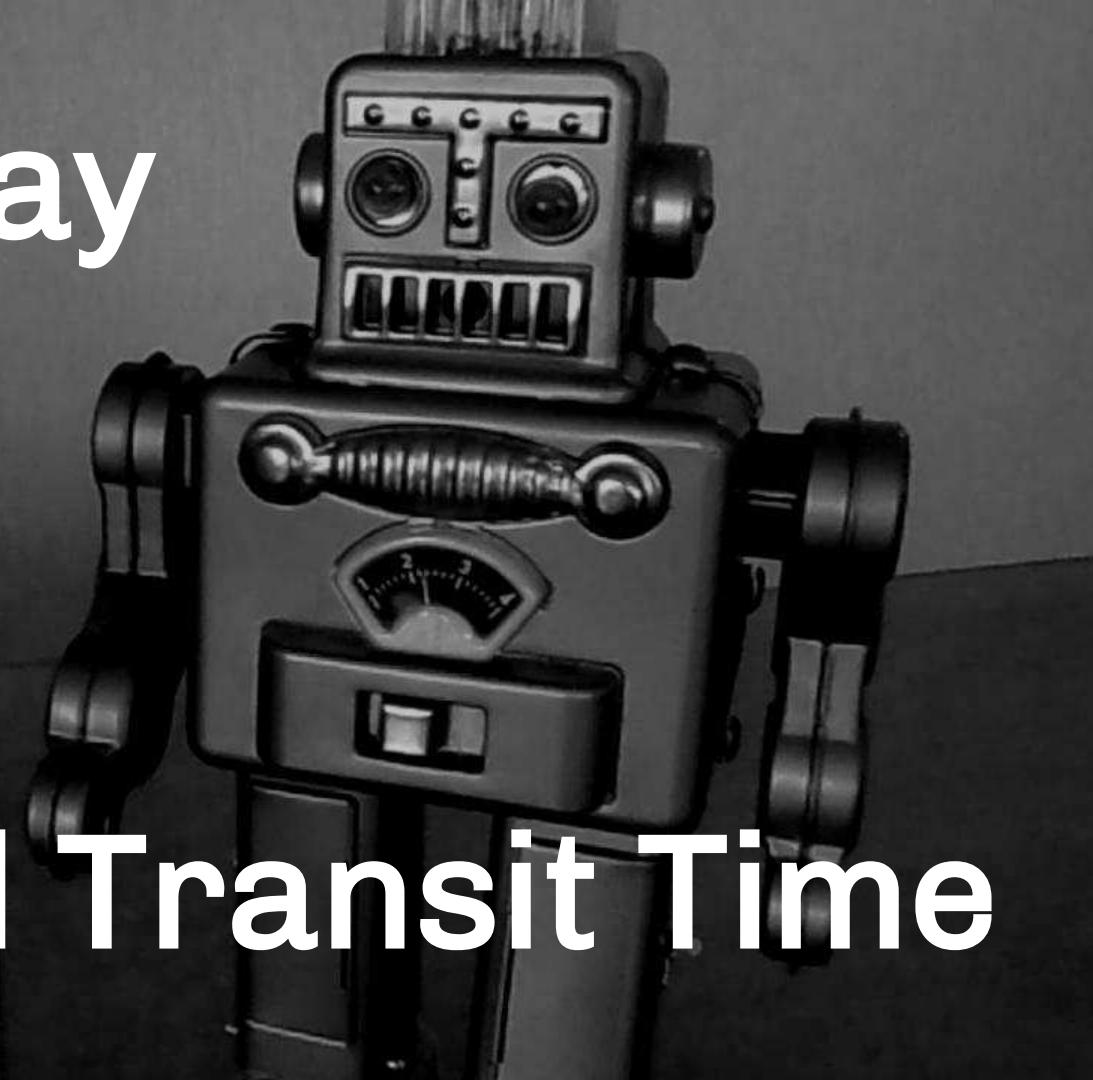
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Want Delay

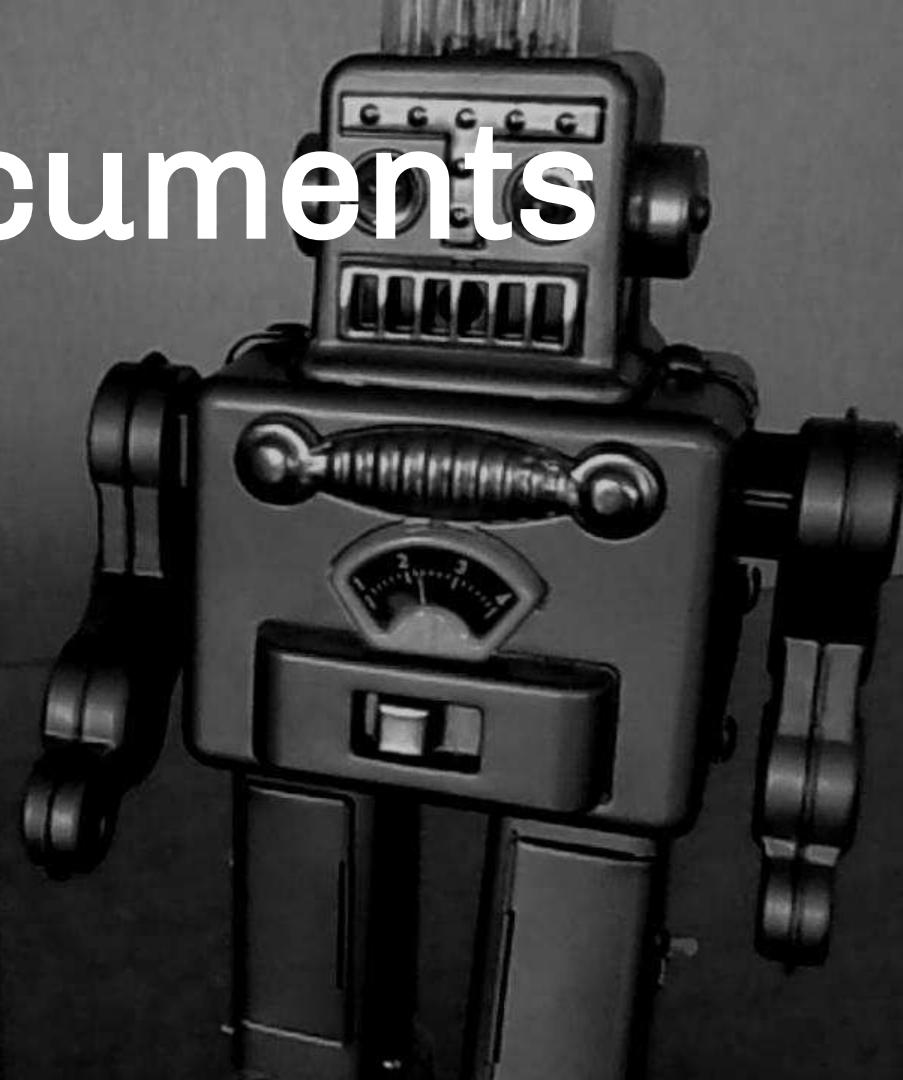


Want Delay



Need Transit Time

JSON Documents



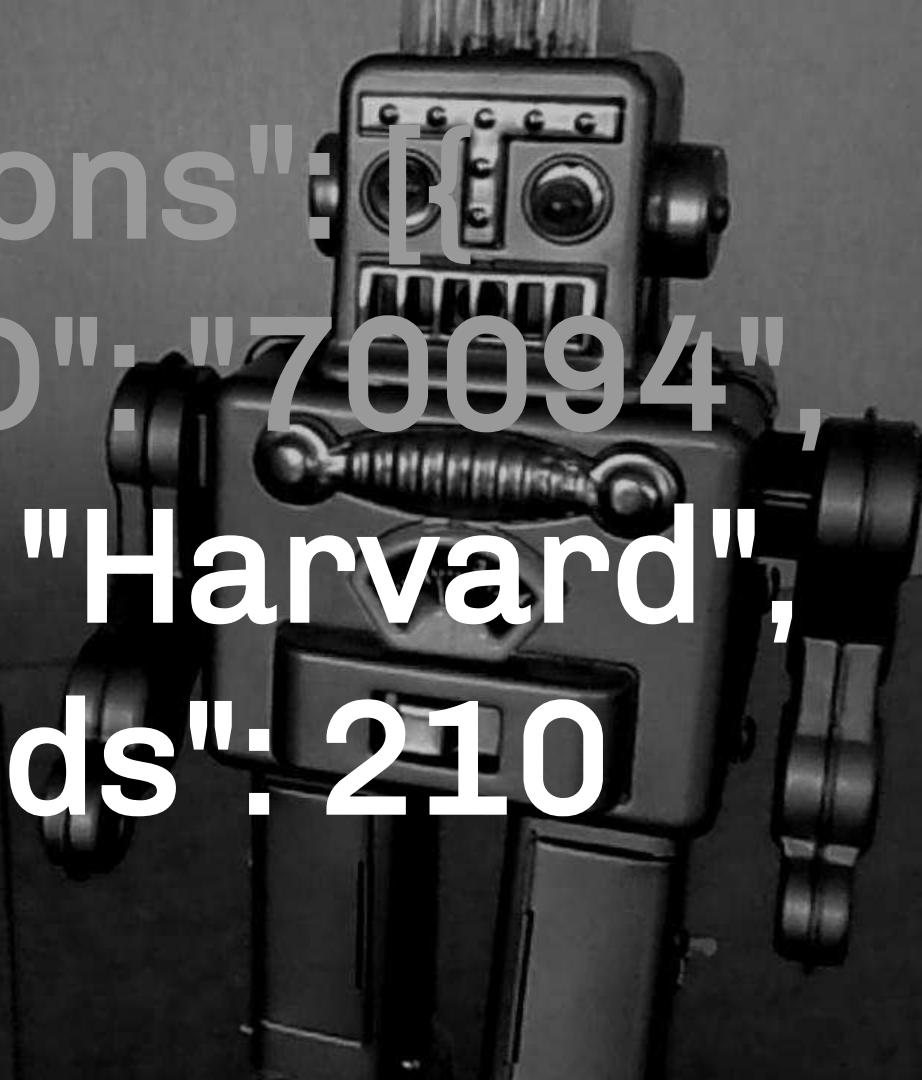
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            "Stop": "Harvard",  
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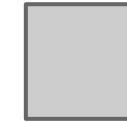
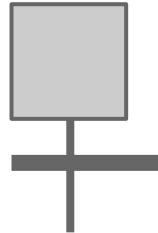
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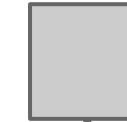
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Time 0



Time 240



**210 Seconds
to Harvard**

**0 Seconds to
Harvard**

240 seconds to get from Central to Harvard

"Trips": [{
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 "Destination": "Alewife",
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"Trips": [

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"Stop": "Harvard",



Trip

R982ECC1E

R98338169

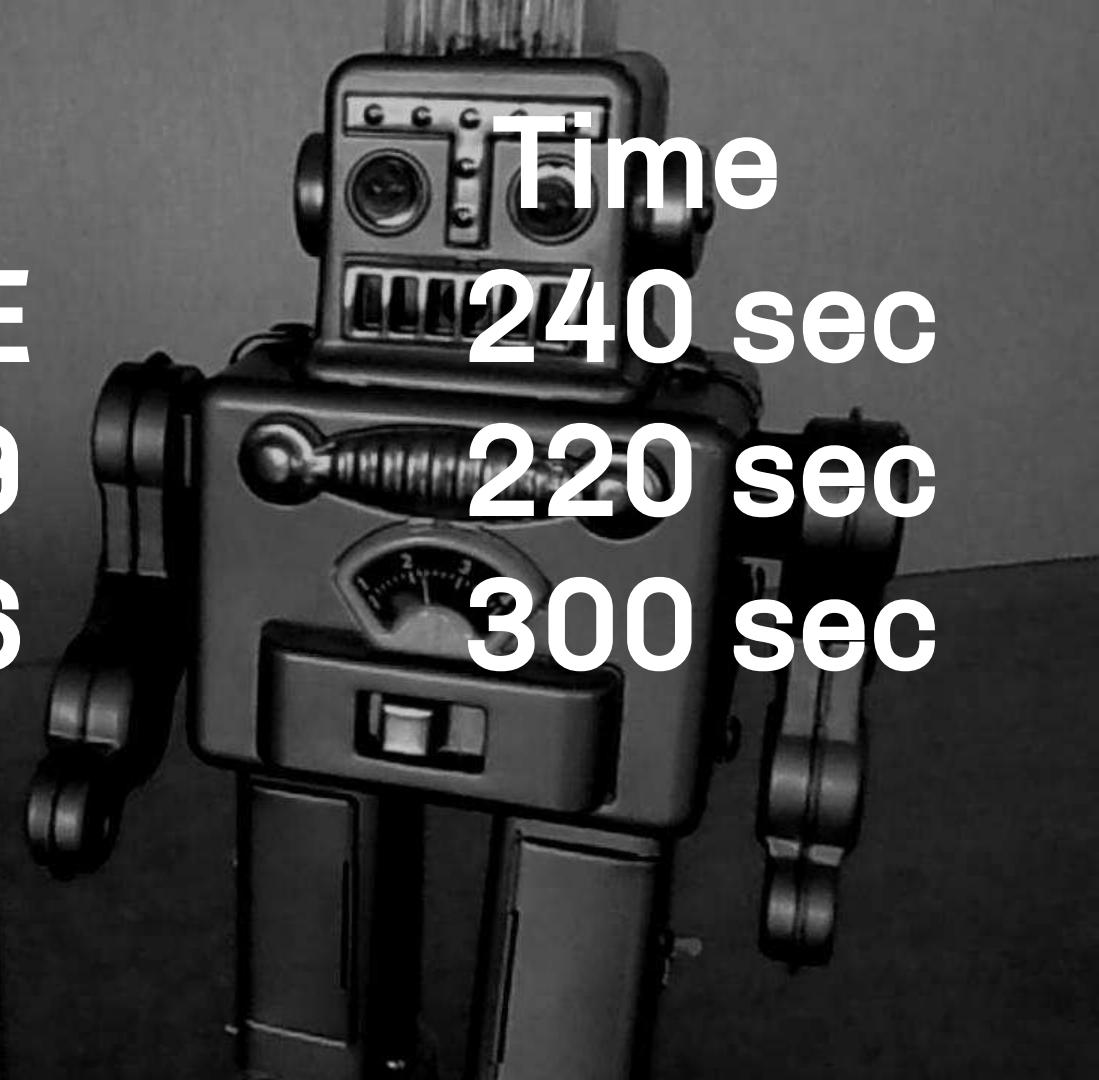
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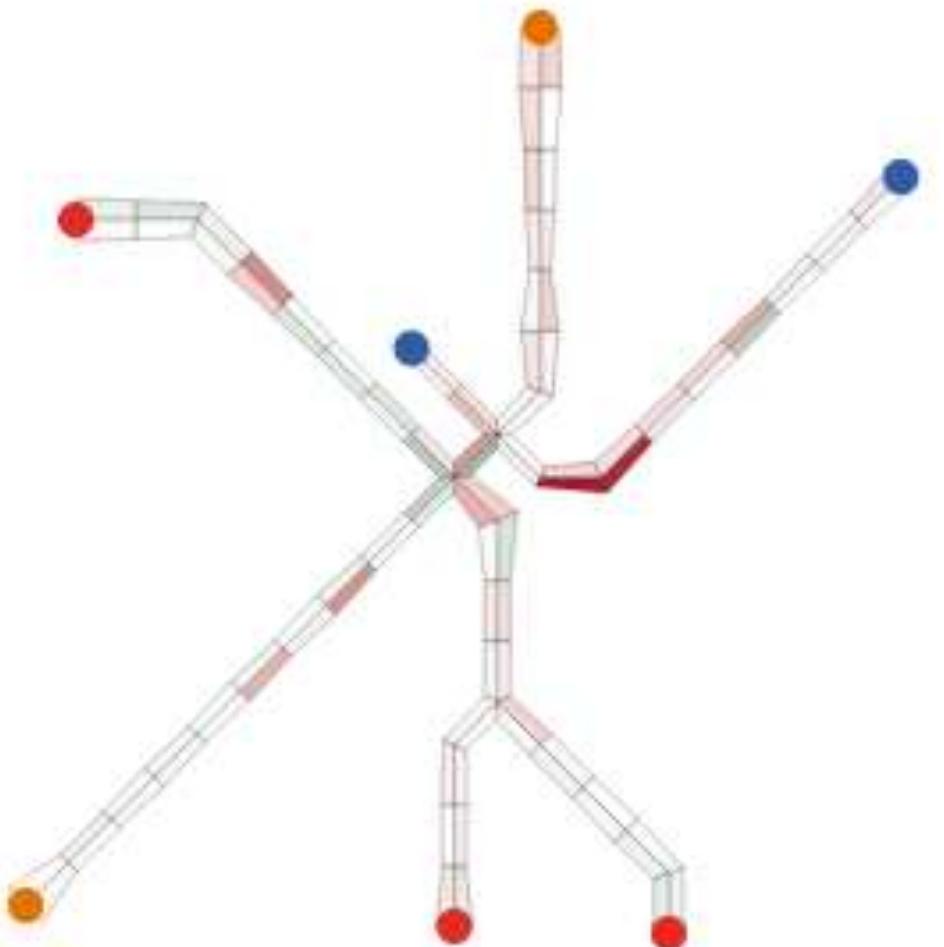
Time

240 sec

220 sec

300 sec





7:32 am on Mon Feb 3

Mon

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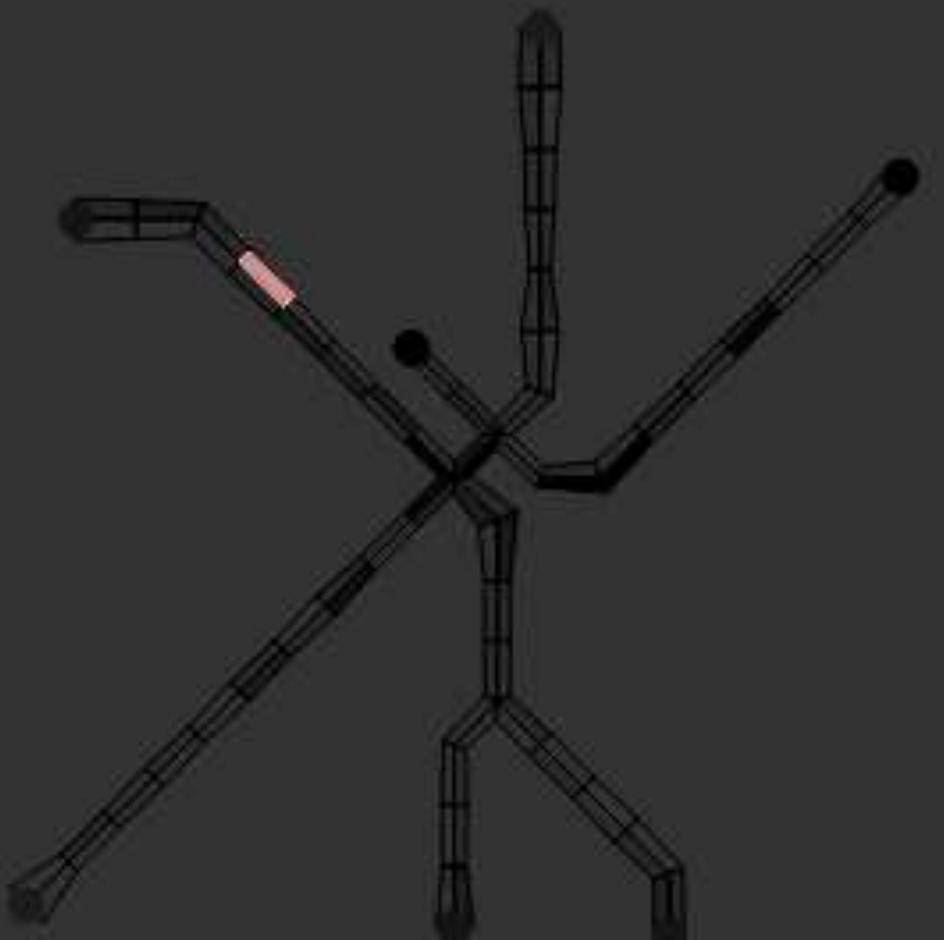
5AM

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9AM

7:32 am 705 C

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7:32 am on Mon Feb 3

1AM 3AM 5AM 7AM 9AM

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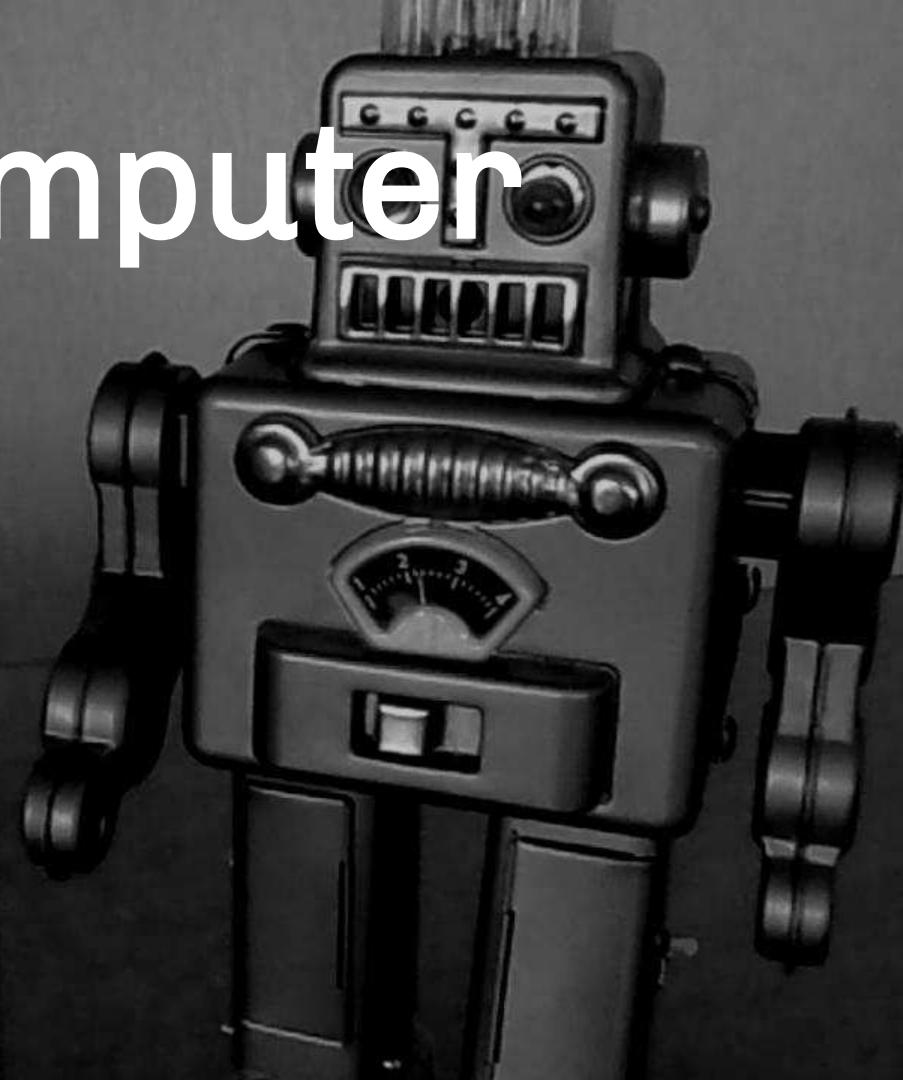
Sat
Feb 8

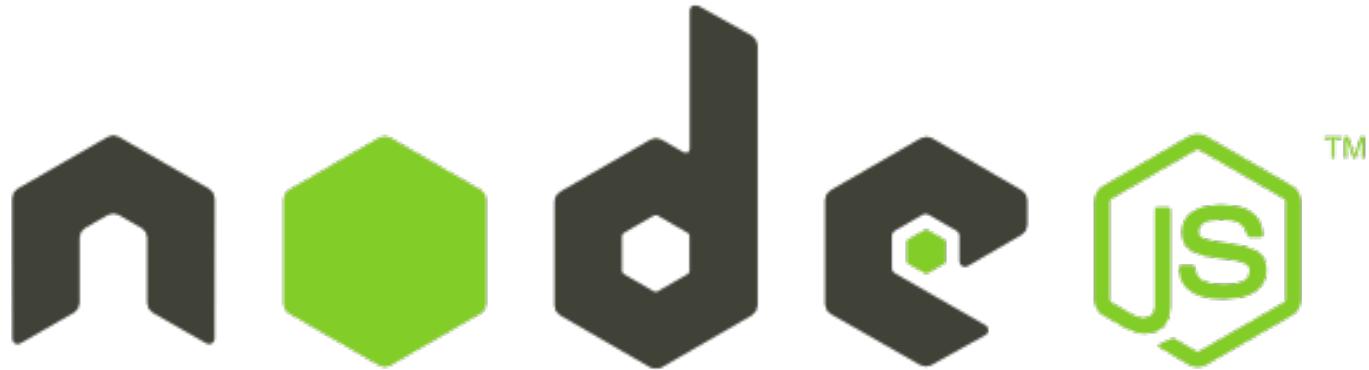
Sun
Feb 9

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296 s

Use A Computer



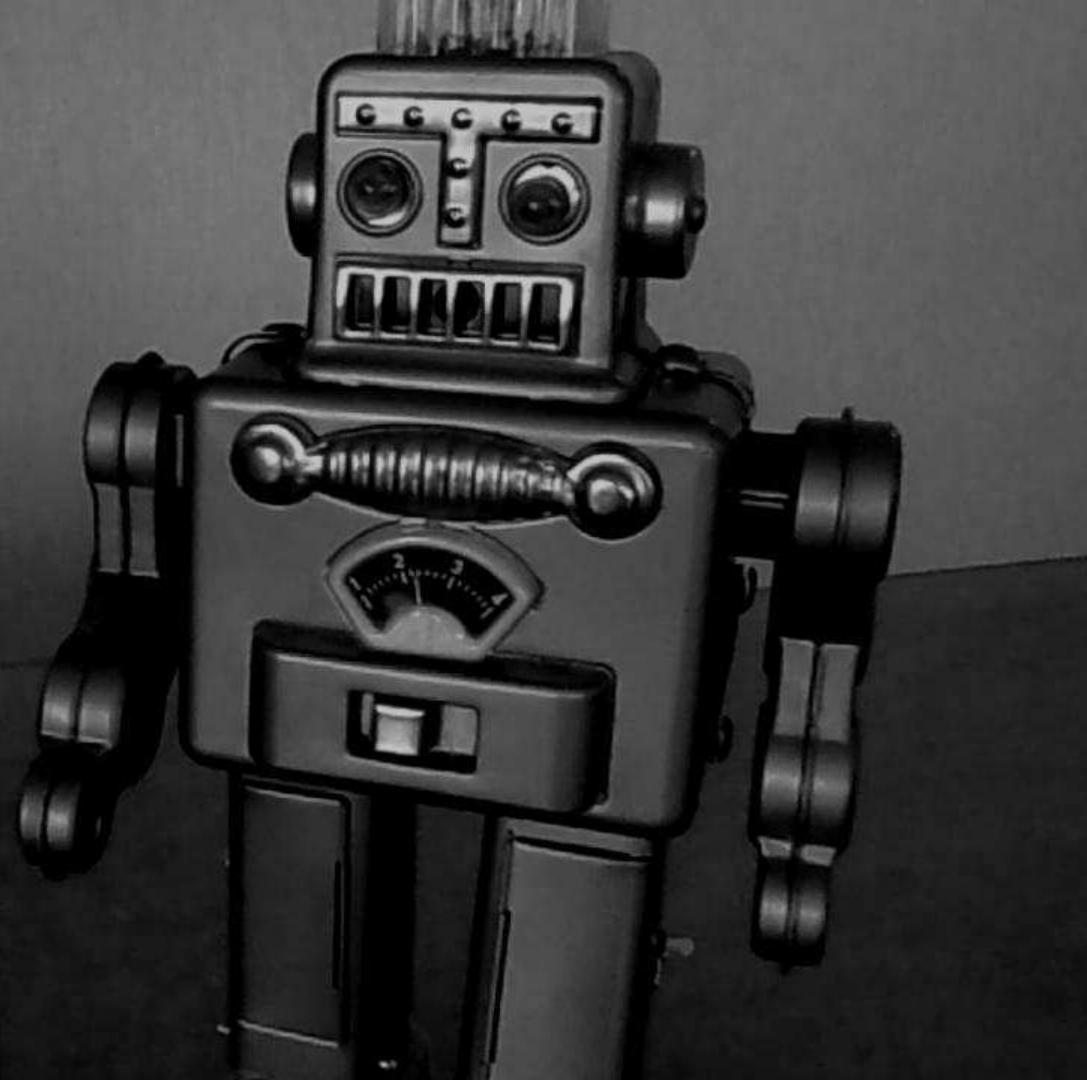


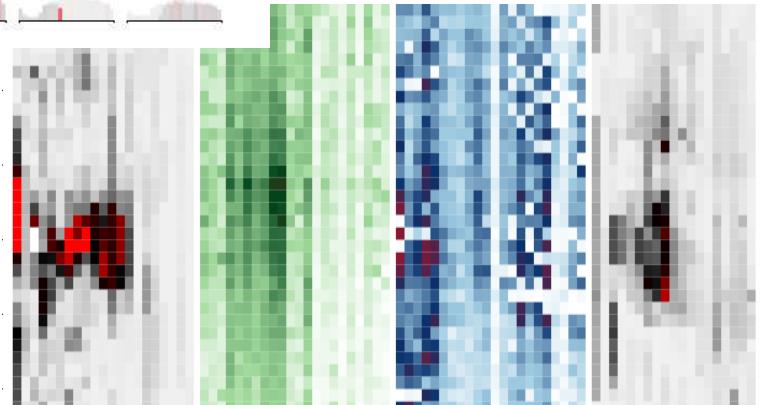
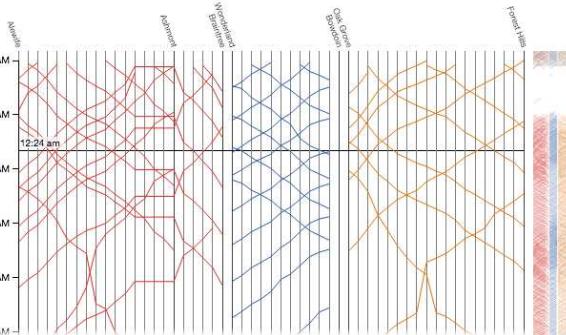
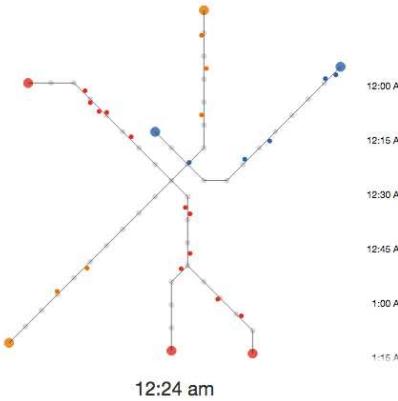
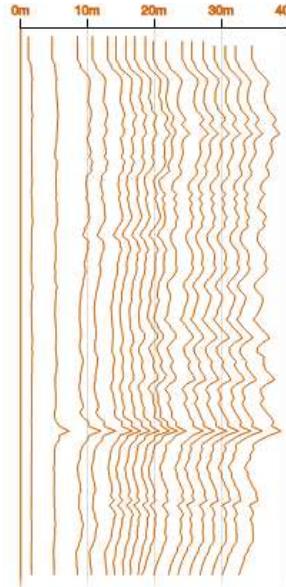
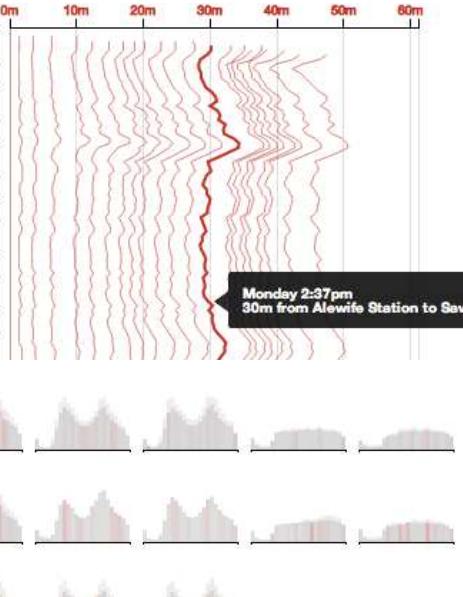
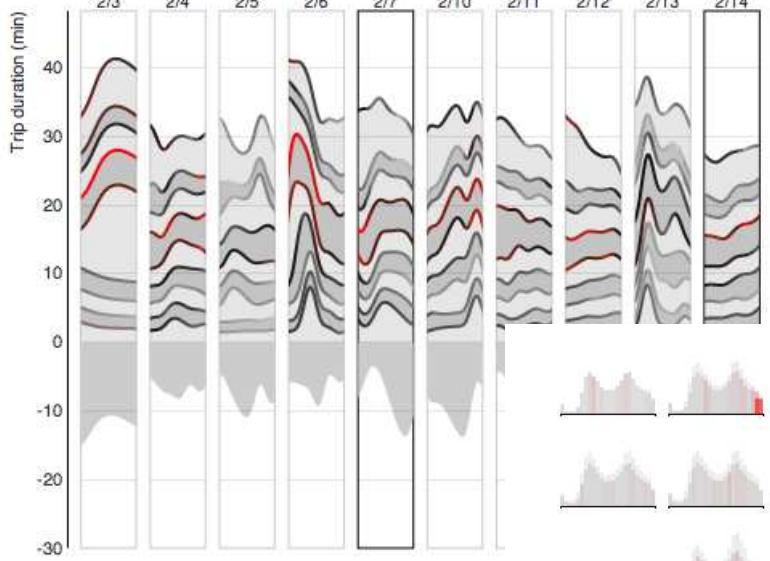




Atlassian
Bitbucket

Iterate!





12:24 am



Putting It All Together

Up and Down the Ladder of Abstraction

A Differentiated Approach to Interactive Visualizations



Matthew W. Bostock, Bret Victor, Mike Bostock
October 2011. worrydream.com/LadderOfAbstraction

— Describing the Ladder of Abstraction

The Ladder of Abstraction is a guide for creating better data visualizations.

It's time to move beyond the theory of theory and the practice of practice.

When you're first learning to program, the best way to learn is by reading the source code of others. In the same way, the best way to learn to make visualizations is by reading the code of others.

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Standing on Concrete

Mike Bostock and Bret Victor — Designing the visual interface for the [sample application](#) on the next page. This is the first step in the ladder of abstraction, and the first step in the ladder of abstraction.

What does it mean to make a visualization concrete? It means that the visualization should have a solid foundation.

That's why they've added a base layer to the visualization. It allows us to make the visualization more concrete, and more useful, by adding a base layer that provides context for the data.

The first step in the ladder of abstraction is to make the visualization more concrete. This is the first step in the ladder of abstraction.

After the first step, we can start to add more abstraction. This is the second step in the ladder of abstraction.

Click to the right to see the next step in the ladder of abstraction.

Concrete is a solid material that is used to support structures. It is also a good material for making buildings.

Controlling Time

Mike Bostock and Bret Victor — Controlling the time dimension. This is the third step in the ladder of abstraction.

Controlling time is a difficult task. Imagine the following situation: You want to control the time dimension, but you don't know how to do it. What do you do?

Now use the slider at the bottom of the visualization to control the time dimension. This is the fourth step in the ladder of abstraction.

Controlling time is a difficult task. Imagine the following situation: You want to control the time dimension, but you don't know how to do it. What do you do?

Now use the slider at the bottom of the visualization to control the time dimension. This is the fourth step in the ladder of abstraction.

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Up and Down the Ladder of Abstraction

Mike Bostock, Bret Victor, Mike Bostock, Bret Victor

October 2011. worrydream.com/LadderOfAbstraction

The Upshot

Is It Better to Rent or Buy?

By MICHAEL KIRKNER AND CHRISTOPHER D. HORN

The choice between buying a home and renting one is among the biggest financial decisions people make in their lives. But it's not always clear what's better. To help you answer this question, our calculator takes the most important costs associated with buying a house and compares the equivalent monthly rent.

Home Price

A very important factor, but not the only one. Our calculator will compare your job and income details below.



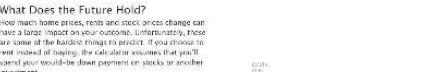
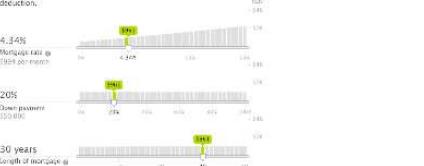
How Long Do You Plan to Stay?

Renting buys you time, but it's better to stay because the upfront fees are spread out over many years.



What Are Your Mortgage Details?

In addition to the interest rate and down payment, the calculator takes into account the mortgage-interest tax deduction.



Bostock, Mike et al. "Is It Better to Rent or Buy?" May 2014. www.nytimes.com/interactive/2014/upshot/buy-rent-calculator.html

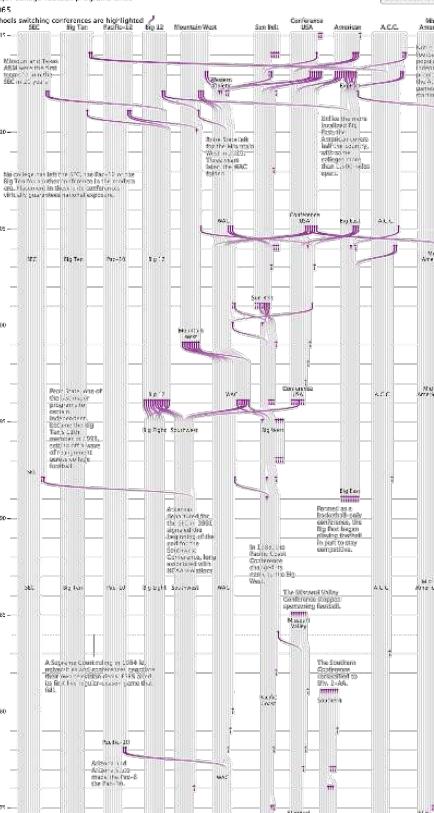
Tracing the History of N.C.A.A. Conferences

By MIKE BOSTOCK

NOVEMBER 30, 2013

A year ago, my colleague Mike Bostock and I traced the history of college football conferences. The effect was substantial: to pay off as programs build new infrastructure to raise their programs, especially in up-and-coming conferences. As conference have become essential to stay competitive, the number of unaffiliated major schools has declined sharply. Here, how major college football programs have shifted since 1965.

Major college football programs since 1965



Bostock, Mike et al. "Tracing the History of N.C.A.A. Conferences." November 2013. www.nytimes.com/newsgraphics/2013/11/30/football-conferences/

The power of the selected node is highly constant. That makes it easier to decide which nodes to include in a visualization.

Algorithms are a frustrating task to visualize. To visualize an algorithm, we need to find the pattern in the data that the algorithm is trying to find. This may be very difficult to visualize, so we need to come up with better communication. This is easier to do with better communication.

But algorithms are also a reminder that visualization is more than just finding patterns in data. It's about finding ways to communicate those patterns in a way that makes them easier to understand and those important abstract processes, and perhaps other things, too.

Sampling

Before I can explain the first algorithm, I first need to explain what it addresses:

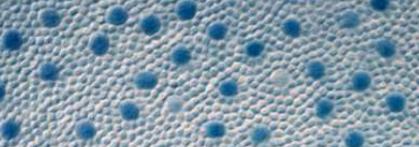


Light — electromagnetic radiation — is light emanating from a screen, traveling through the air, focused by a lens and projected onto the retina — is a continuous signal. To be perceived, we must reduce this intense impulse by measuring its intensity and frequency distribution at different locations.

This reduction process is called sampling and is essential in optics. You can think of it as a point applying a discrete number of colors to form an image that includes blurry artifacts.

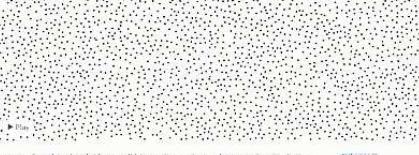
Environment lighting is often a collection of infinite points in space, for example, to simulate a 3D scene by rendering, we make decisions where certain pixels receive which color, resulting in image rendering.

Sampling is made difficult by competing goals. On the one hand, samples should be evenly distributed so there are no gaps. But we must also avoid creating regular patterns, which cause artifacts. This is why you should never study objects that are made of regular patterns with the grid of pixels in the camera sensor and Grade 5000, for example.



This image contains a regular grid of dots representing a Poisson disk distribution. The dots cover the area uniformly and randomly to prevent the artifacts that can arise if the dots are too close together and the cells relative positions are regular. This is called a Poisson disk distribution because most sites a minimum distance apart from each other, avoiding collision and unwanted interference.

Unfortunately, creating a Poisson disk distribution is hard. Check out that in a bit. So here's a simple approximation known as Mitchell's local candidate algorithm.



You can see that these dots from candidate sampling produce a pleasing random distribution.

Bostock, Mike. "Visualizing Algorithms." June 2014. bostocks.org/mike/algorithms

Outline

File Edit View Insert Format Tools Table Add-ons Help Last edit was on April 19, 2014

Comments

Share



<< insert lined-up marey here >>

The People

In a typical weekday, over 400,000 people enter a station along the red, orange, or blue lines. On Saturdays and holidays that number drops to 230,000 and on Sundays it drops to 160,000. The busiest day was Friday February 7 when 470,187 people entered the system.

This shows the total number of entries and exits for the red, orange, and blue line for every hour over the entire month. You can see weekends and holidays, as well as daily peaks around rush hour. Our exit data is unreliable since not all stations measure require that people exit through a turnstile|

<< Render a single row of the turnstile heatmap for sum of all stations >>

The busiest stations are all along the Red Line. Harvard topped the list, followed closely by South Station, and then Downtown Crossing. The graphic below shows turnstile entries over time across all stations.

<< Render the turnstile heatmap, sortable by position along the line or entries/decreasing >>

How People and Trains Affect Each Other

When you look back at the Marey diagram, the slope of each line tells you how fast a train is going and the time it takes to get between stations. When all of the start and stop times are lined up you can see a drastic variation in the time it takes to get between stops throughout the day. If you have ever ridden the subway during rush hour then you have experienced what the steep lines in the Marey diagram feel like first-hand.

What causes these delays? It's hard to know for sure, but what we can determine is that delays usually happen when more people are riding the subway. The next visualization shows this correlation.

<<figure out a graphic here that shows correlation between crowds and delay>>

But how do these crowds and delay typically affect you on your commute? Choose the two stations you typically commute between on a line

Red Line (laid out vertically)

Orange Line

Blue Line

A Month in the Life of the MBTA

An exploration of ridership and the trains of Boston

Michael Barry & Brian Card

Boston's Massachusetts Bay Transit Authority (MBTA) operates the 4th busiest subway system in the U.S. after New York, Washington, and Chicago. If you live in or around the city you have probably ridden on it. You may remember subway riders that were stuck on cars that were crowded, or even worse, stranded. When you get off the train, that was slow, can't see the tracks until you need to ride it again. It's hard to know if you left at a different time if the trains would be less crowded or what the experience is like on the other side of the system.

The MBTA publishes a substantial amount of subway data. They provide the full schedule in General Transit Feed Specification (GTFS) format which powers Google's transit directions. They also publish real-time train locations for the Red, Orange, and Blue lines (but not Green or Silver). We collected real-time data for the entire month of February, 2014. Also, working with the MBTA, we were able to acquire per-minute entry and exit counts at each station measured at the turnstiles used for payment.

We attempt to present this information to help people in Boston better understand the trains, how people use the trains, and how the people and trains interact with each other.

The Trains

In a typical weekday, trains make approximately 1150 trips on the red, orange, and blue lines starting at 5AM and continuing through 1AM the next morning. On Saturdays trains make 870 trips and on Sundays they make 762.

The visualization below shows all of these trips that trains took on the red, orange, and blue lines on February 18, 2014. Each vertical line represents a station and line extends from top to bottom to show the time of day. This visualization was first used by Etienne-Jules Marey and is typically called a "Marey Diagram".

	Average Subway Trips per Day		
	Weekdays	Saturdays	Sundays
Red	450	320	380
Orange	250	200	240
Blue	300	220	240
Total	1,000	870	762

To better compare these individual trips, we line up the starting points so you can see the range of fastest to slowest trips, as well as variation. (describe a couple of notable trips, where hovering over them dims all of the others)

The People

In a typical weekday, over 400,000 people enter a station along the red, orange, or blue lines. On Saturdays and holidays that number drops to 230,000 and on Sundays it drops to 160,000. The busiest day was Friday February 7 when 470,187 people entered the system.

This shows the total number of entries and exits for the red, orange, and blue line for every hour over the entire month. You can see weekends and holidays, as well as daily peaks around rush hour. Our exit data is unreliable since not all stations measure require that people exit through a turnstile.

The busiest stations are all along the Red Line. Harvard topped the list, followed closely by South Station, and then Downtown Crossing. The graphic below shows turnstile entries over time across all stations.

How People and Trains Affect Each Other

When you look back at the Marey diagram, the slope of each line tells you how fast a train is going and the time it takes to get between stations. When all of the start and stop times are lined up you can see a drastic variation in the time it takes to get between stops throughout the day. If you have ever ridden the subway during rush hour then you have experienced what the steep lines in the Marey diagram feel like first-hand.

What causes these delays? It's hard to know for sure, but what we can determine is that delays usually happen when more people are riding the subway. The next visualization shows this correlation.

But how do these crowds and delay typically affect you on your commute? Choose the two stations you typically commute between on a line

Summary

Through publicly available data, we have the tools to understand the subway system better than we ever have before. We have seen how the system operates on a daily basis, how people use the system and how that affects the trains, and how the trains and people affect you.

Through our analysis and the real-time data feeds, you can also take these insights with you wherever you ride the train. Bookmarks.meteor.com on your mobile phone and you can check it any time to see up-to-the-minute congestion and delay information.



10 Days Left

```
commit b2fb7010ca3222ba7a987b5f85ddaf2c7a604192
Author: Mike Barry
Date:   Fri Apr 18 08:13:13 2014 -0400

Initial commit of final project
```

```
.
  ├── app
  │   ├── index.html
  │   ├── bower.json
  │   ├── Gruntfile.js
  │   ├── package.json
  │   └── README.md
```

```
commit b2fb7010ca3222ba7a987b5f85ddaf2c7a604192
Author: Mike Barry
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```

```
.  
    app  
    |__ index.html  
    |__ bower.json  
    |__ Gruntfile.js  
    |__ package.json  
    |__ README.md
```

```
commit c63f5989df5b014abacafc1bb92b53e3bc8ebb54
Author: Mike Barry
Date:   Tue Apr 22 06:47:40 2014 -0400

    try out MBTA theme
```

```
commit e0d609dc509724aa201429fe5e42c0f82ebf9ca2
Author: Mike Barry
Date:   Sun Apr 27 17:20:32 2014 -0400

    fix math :-(
```

```
commit b2fb7010ca3222ba7a987b5f85ddaf2c7a604192
Author: Mike Barry
Date: Fri Apr 18 08:13:13 2014 -0400

Initial commit of final project
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fix math :-(
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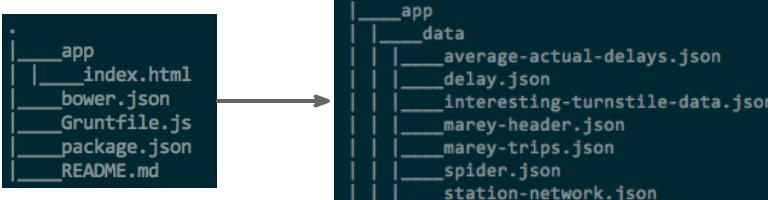
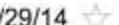
Michael Barry

to Matt, Brian

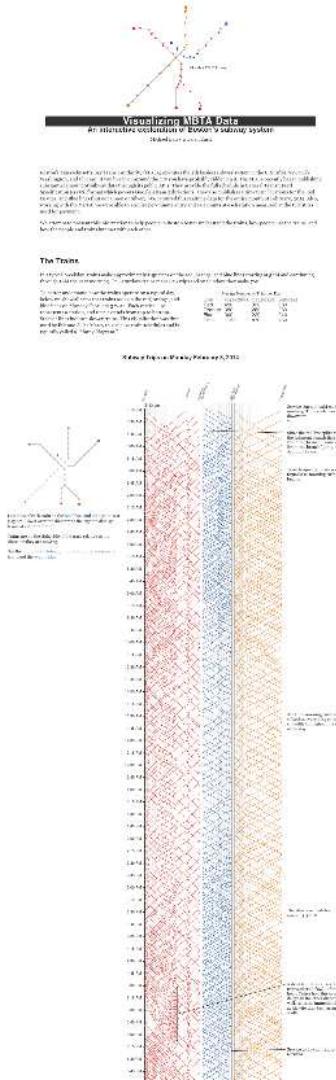
Professor Ward,

Here is the final paper and project for CS525D for Mike Barry and Brian Card.

⌚ 4/29/14 ⭐

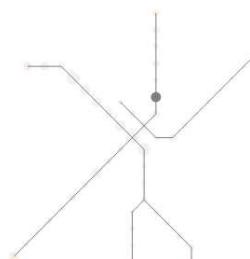
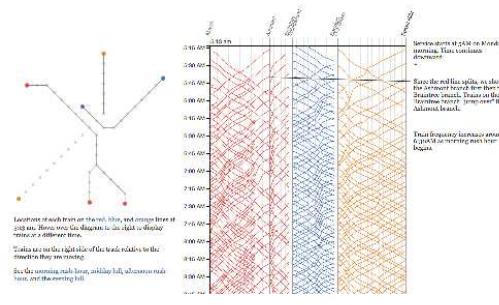
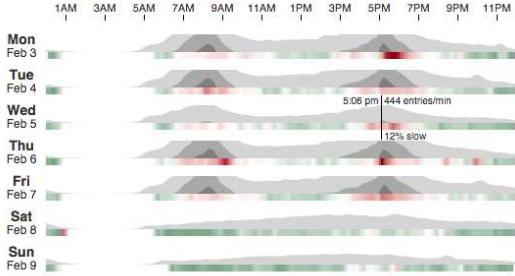
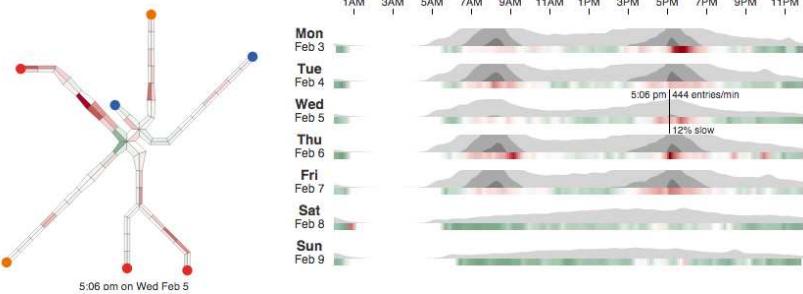
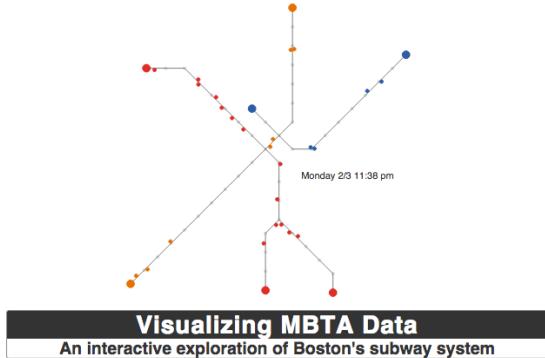


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turnstile-heatmap.json  
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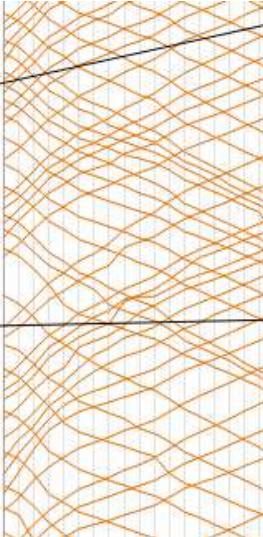
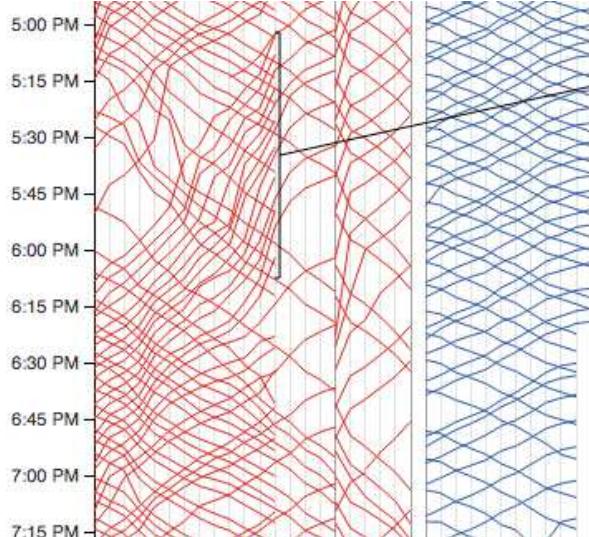
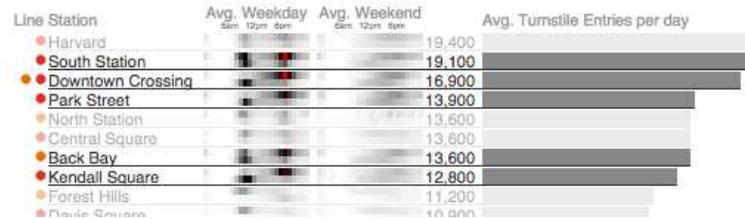
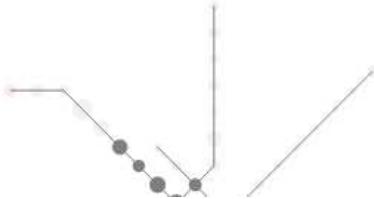


If You Find
Something That
Works, Run with It



Line/Station	Avg. Weekday Sun Mon Tue	Avg. Weekend Sun Mon Tue	Avg. Turnstile Entries per day
Harvard	19,400	19,100	
South Station	19,100	18,900	
Downtown Crossing	18,900	18,900	
Parlour Square	13,900	13,600	
North Station	13,600	13,600	
Central Square	13,600	13,600	
Back Bay	13,600	12,800	
Kendall Square	12,800	12,800	
Forest Hills	11,200	10,900	
Davis Square	10,900	9,400	
State Street	9,400	9,100	
Marblehead Center	9,100	8,900	
Haymarket	8,900	8,800	
Charles MGH	8,800	8,800	
Fuggles	8,800	8,400	
Maverick	8,400	8,300	
Sullivan Square	8,300	8,200	
Alewife	8,200	7,400	
Government Center	7,400	7,400	
Poiter Square	7,400	7,200	
JFKU Mass	7,200	6,900	
Ashmont	6,900	6,500	
Quincy Center	6,500	—	

When entries and exits are broken down by station, you can see the busiest stations are all along the Red Line. Harvard topped the list, followed close by South Station , and then Downtown Crossing . Next to each station are heatmaps showing entrances and exits to each station per-hour for weekdays and weekends/holidays. You can see that some stations are work stations since their exits peak in the morning and entrances peak in the afternoon and that some stations are home stations since their entrances peak in the morning and exits peak in the afternoon. Some stations are just busy all the time. Hover over a stop to see where it on the map on the left. Click a stop to show a detailed heatmap below.



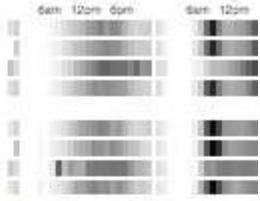
A disabled train causes delays on trains after (below) it for over an hour. Notice how this causes delays in the other direction as well, as trains immediately arrive at Alewife then turn around to go south.

Service to Bowdoin stops at 6:20PM

Normal service resumes for the evening starting around 7PM

Harvard

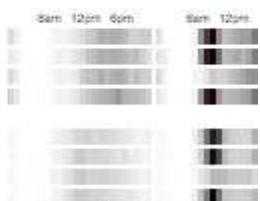
19,400 per day
21,600 weekdays
14,900 weekends
[hide this station](#)



Harvard is the busiest station and has a const

South Station

19,100 per day
24,100 weekdays
8,600 weekends
[hide this station](#)



In the heart of Boston's Financial District, So the end of the commuter rail and people who the commuter

A dark, close-up photograph of a watch face. The watch has a black dial with Roman numeral hour markers. The brand name "MONTINARI MILANO" is printed diagonally across the dial. The word "QUARTZ" is also visible near the bottom right. The background is dark and out of focus.

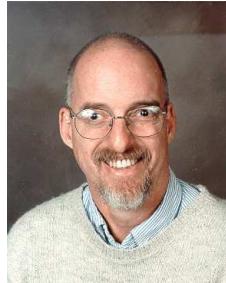
Get Feedback



Done?

A Few More Things...

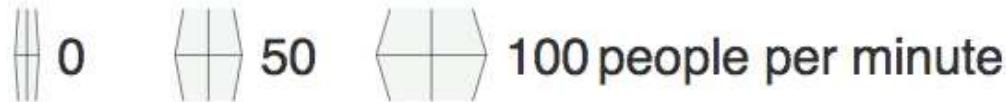
- Respond to feedback
- Cross-browser and mobile testing
- Your commute
- Web hosting
- Marketing



Size shows turnstile entries on average day

◦ 500 ◦ 10,000 ◦ 19,400 people per day

Line width shows turnstile entries at a station



Color shows delay



Gray bars show entries to all stations



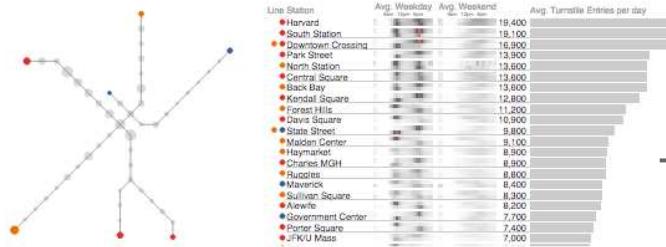
Color shows average entrances/exits



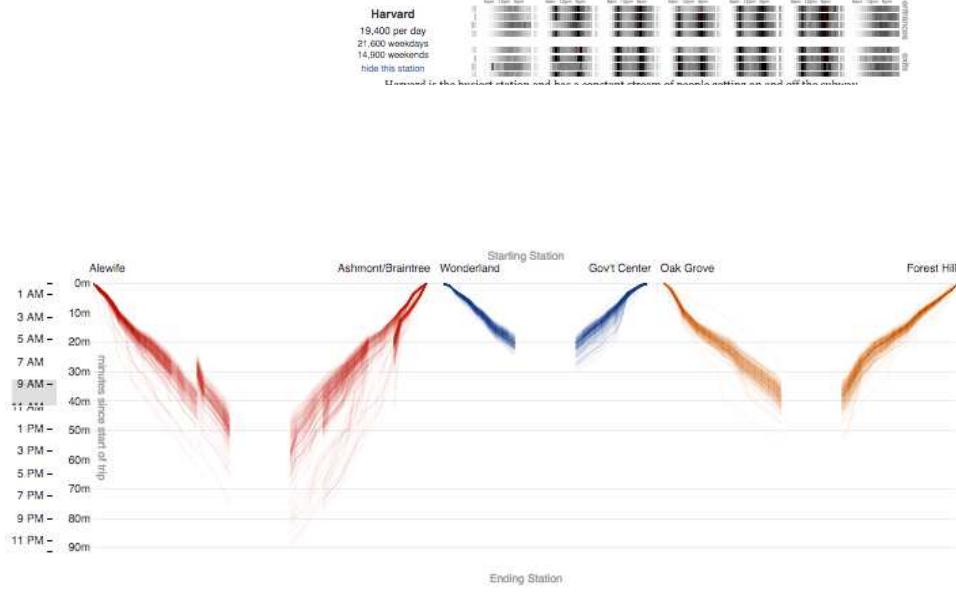
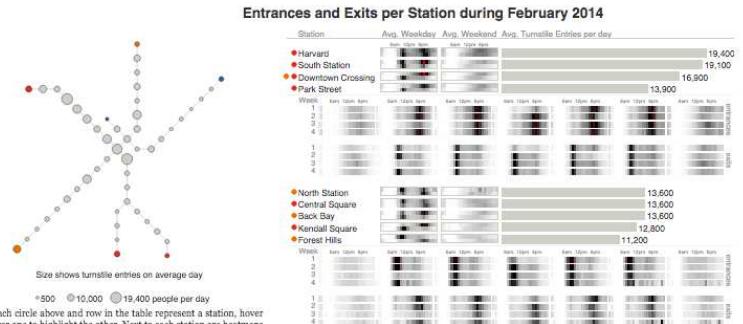
WPI



BeehiveMedia



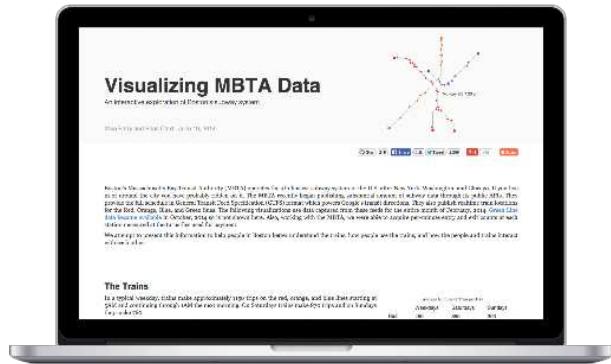
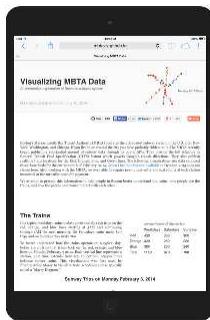
Click a station above to show a detailed breakdown of entrances/exits per hour during the month of February below.





+ My Dad

BeehiveMedia 



Visualizing MBTA Data
An interactive exploration of Boston's subway system

Mike Barry and Brian Carr - June 10, 2014



MBTA's Massachusetts Bay Transit Authority (MBTA) operates the 4th busiest subway system in the U.S. after New York, Washington, and Chicago. When you live in or around the city you have probably ridden on it. The MBTA recently began publishing substantial amounts of subway data through its public API. They provide data for all 4 lines (Red, Blue, Green, Orange), and for the light rail (Silver Line). This data includes trip start and end locations, and for the Red, Orange, Blue, and Green lines, the following visualizations use data captured from these feeds for the entire month of February, 2014. (Green Line data source available in October, so it is not shown here.) Also, working with the MBTA, we were able to acquire per station entry and exit counts at each station along all of the lines.

We attempt to present this information to help people better understand the routes, how people use the trains, and how the people and transit interact with each other.

The Trains

In typical weekday, riders make approximately 100,000 trips on the red, orange, and blue lines starting at 5AM and continuing through AM and the two morning off-peak hours trains make their first stop on Redline they start at 5PM.

24-hour subway line data indicates a typical day, below are 24 hour line trip data that break down the red, orange, and blue lines on Monday February 3rd. Blue line vertical line represents a station, and most indicate three trip as follows. Longer lines indicate slower trains. The data was first used by Beehive Media to demonstrate a mobile and a "Mobile Diagram".

Subway Trips on Monday February 3, 2014

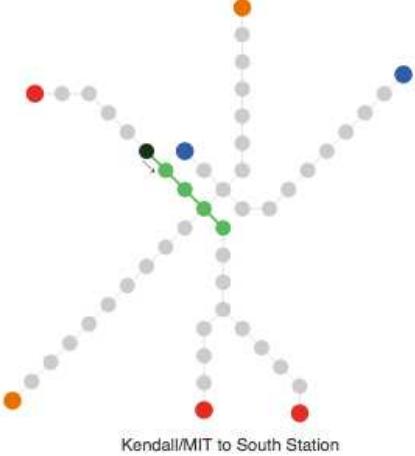
Line	Weekdays	Weekends	Blended
Red	450	350	380
Blue	360	280	295
Orange	1100	800	980



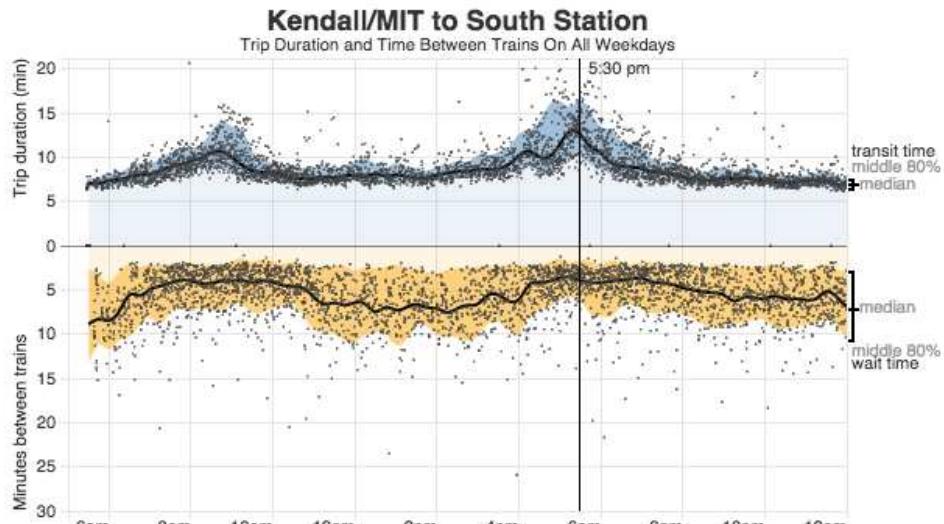




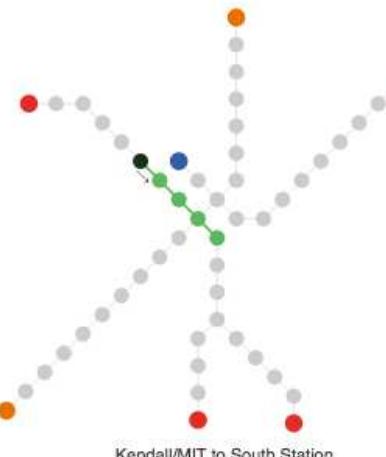
But How Long Is
My Commute?



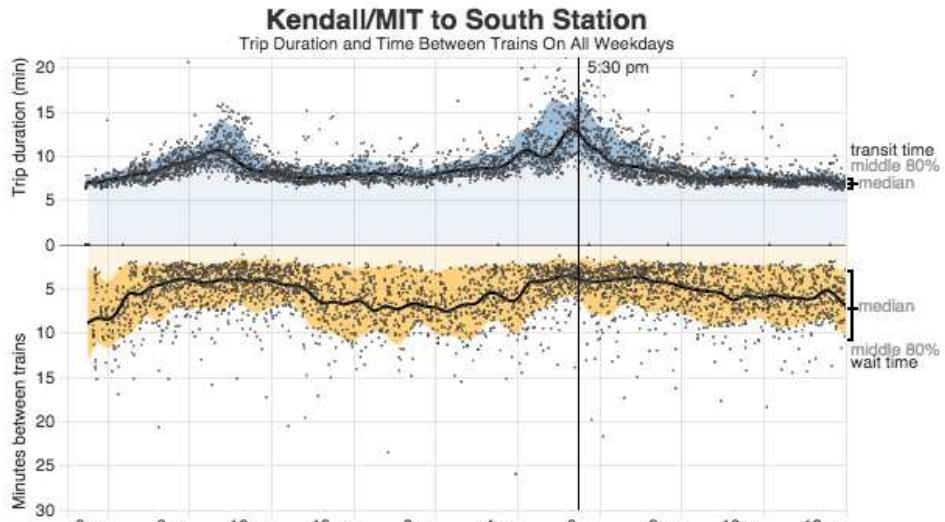
Drag from a starting station to an ending station to see how long the trip takes over time in the chart.



At 5:30 pm trains leave every 1 to 6 minutes from Kendall/MIT going to South Station. The trip takes between 10 and 17 minutes. The shortest time from when you walk into Kendall/MIT until you walk out of South Station is 10 minutes but it can be as long as 23 minutes. Usually it takes about 15 minutes including wait and transit time.



Drag from a starting station to an ending station to see how long the trip takes over time in the chart.



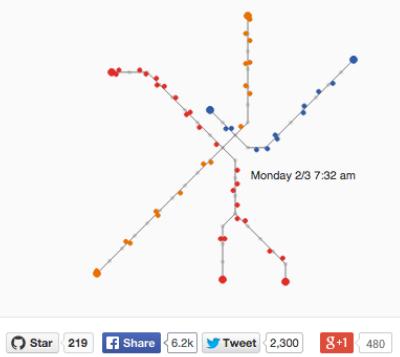
GitHub Pages

git push origin master → <http://mbtaviz.github.io>

Visualizing MBTA Data

An interactive exploration of Boston's subway system

Mike Barry and Brian Caro - June 10, 2014



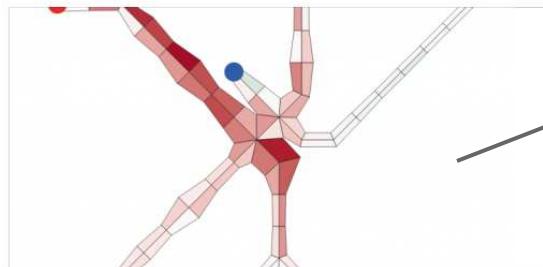
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1

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Visualizing MBTA Data

An interactive exploration of ridership, congestion, and delay on Boston's subway system.

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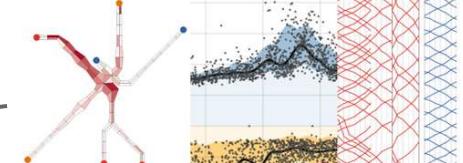


Mike Barry @msb5014

The card for your website will look a little something like this!



Mike Barry



Visualizing MBTA Data

By Mike Barry @msb5014

An interactive exploration of ridership, congestion, and delay on Boston's subway system.

[View on web](#)

June 10 2014



798
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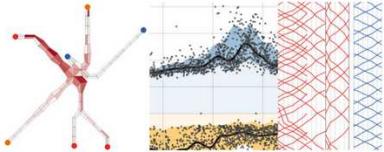
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 **Mike Barry**
@msb5014 

A modern take on train visualizations, inspired by
@EdwardTufte and @worrydream [mbtaviz.github.io](#)

8:44 AM - 10 Jun 2014



Visualizing MBTA Data
An interactive exploration of ridership, congestion, and delay on Boston's subway system.

 Mike Barry @msb5014

173 RETWEETS 176 FAVORITES

9:00 AM

12:00 PM

3:00 PM

6:00 PM

9:00 PM



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@msb5014 Very impressive!

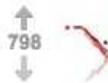
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9:00 PM



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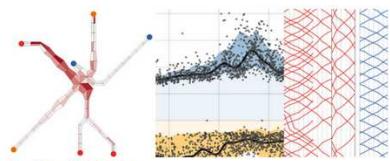
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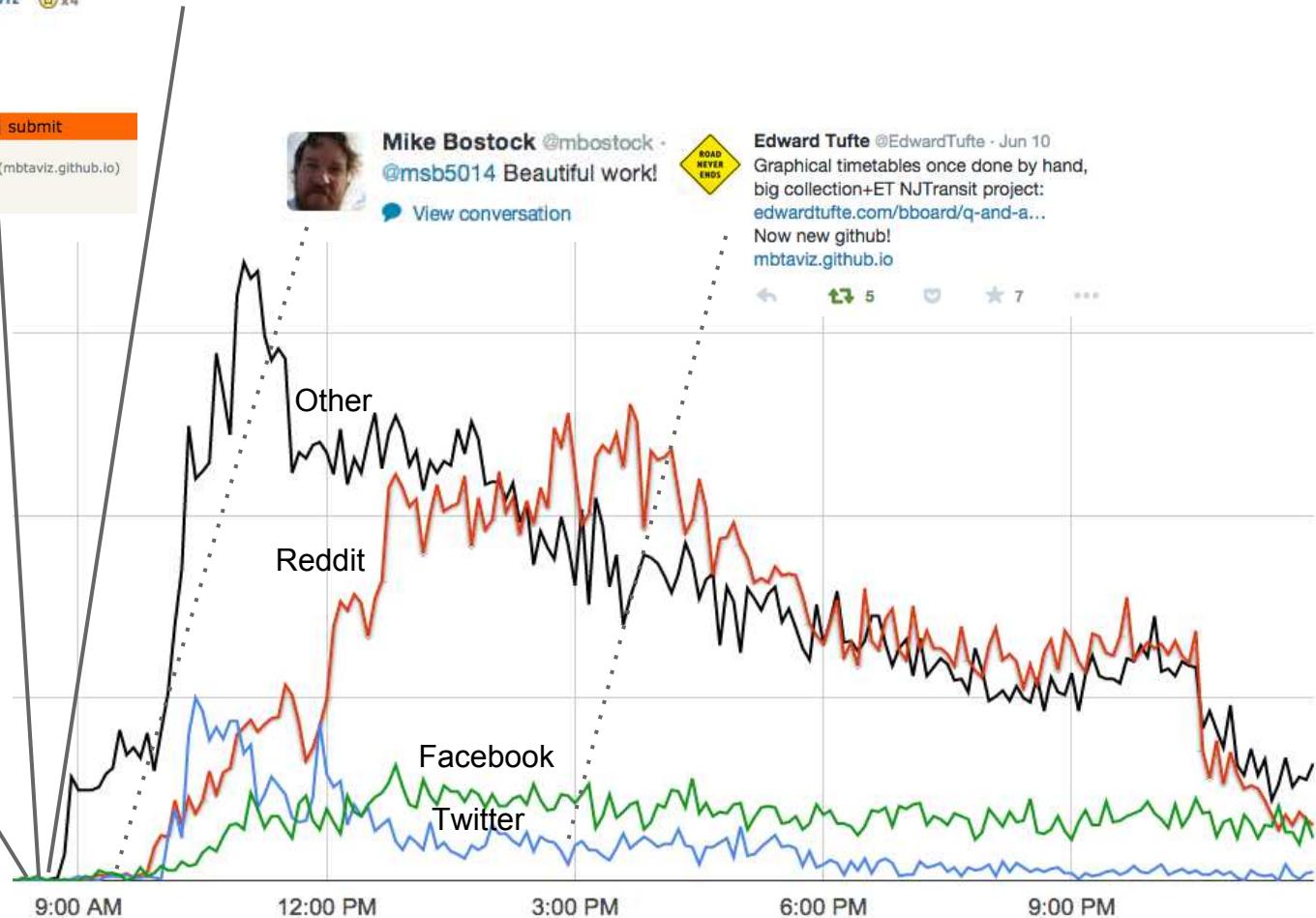
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173 RETWEETS 176 FAVORITES



Visualize All the Things

- All the free tools you need are at your fingertips
- Focus on answering questions
- Learn from the best
- Find your tools and stick with them

Questions? Thank you!

Mike Barry @msb5014
Brian Card @bmcard

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