Big Data

Lawrence Snyder
University of Washington, Seattle

Big Data

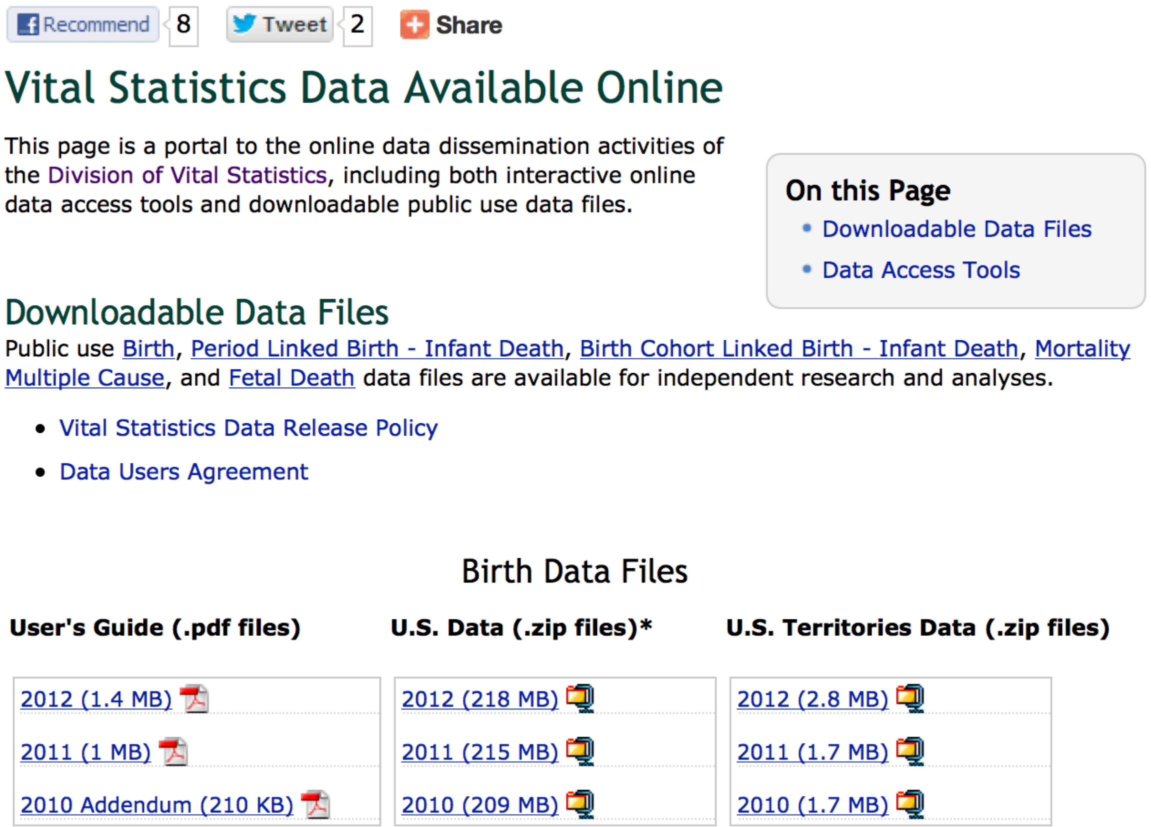
- "Big data" refers to the analysis of any large corpus of data to extract information, usually by means of statistical techniques
- We've already seen big data in action
  - In Target's analysis of purchasing behavior to determine if a woman is pregnant
  - In Google's Page Rank, their estimate of how significant a page is
- Today we discuss big data … but there is a limit to how big it can get in a lecture!

Where is Big Data Found?

- Data is everywhere –
  - All Facebook users constitute a data archive that Facebook analyzes continually
  - Google has crawled the WWW for years … their data is truly big!
  - Census bureau
  - UW's student database
  - Every company's consumer records
  - Governmental DBs like licensing, tax revenues ,etc.
  - …

More Than No.s

- Data that is regularly gathered for some purpose typically contains a lot more information than the recorded numbers reveal … and it's often easy to get



Vital Statistics Data Available Online

This page is a portal to the online data dissemination activities of the Division of Vital Statistics, including both interactive online data access tools and downloadable public use data files.

On this Page

- Downloadable Data Files
- Data Access Tools

Downloadable Data Files

Public use Birth, Period Linked Birth - Infant Death, Birth Cohort Linked Birth - Infant Death, Mortality Multiple Cause, and Fetal Death data files are available for independent research and analyses.

- Vital Statistics Data Release Policy
- Data Users Agreement

Birth Data Files

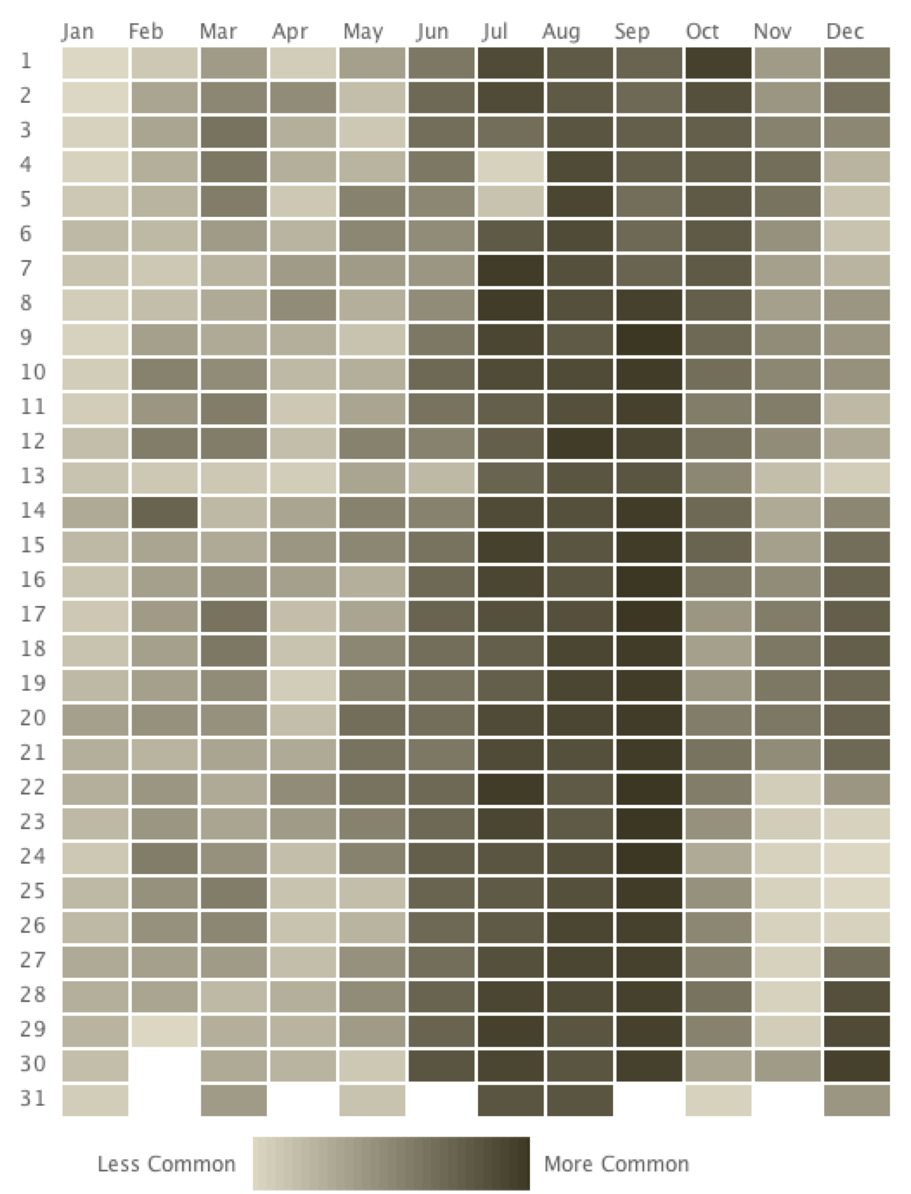
User's Guide (.pdf files)	U.S. Data (.zip files)*	U.S. Territories Data (.zip files)
2012 (1.4 MB)	2012 (218 MB)	2012 (2.8 MB)
2011 (1 MB)	2011 (215 MB)	2011 (1.7 MB)
2010 Addendum (210 KB)	2010 (209 MB)	2010 (1.7 MB)

More Than No.s

- The data used for our "heat map" of birthdays came from birth certificate records

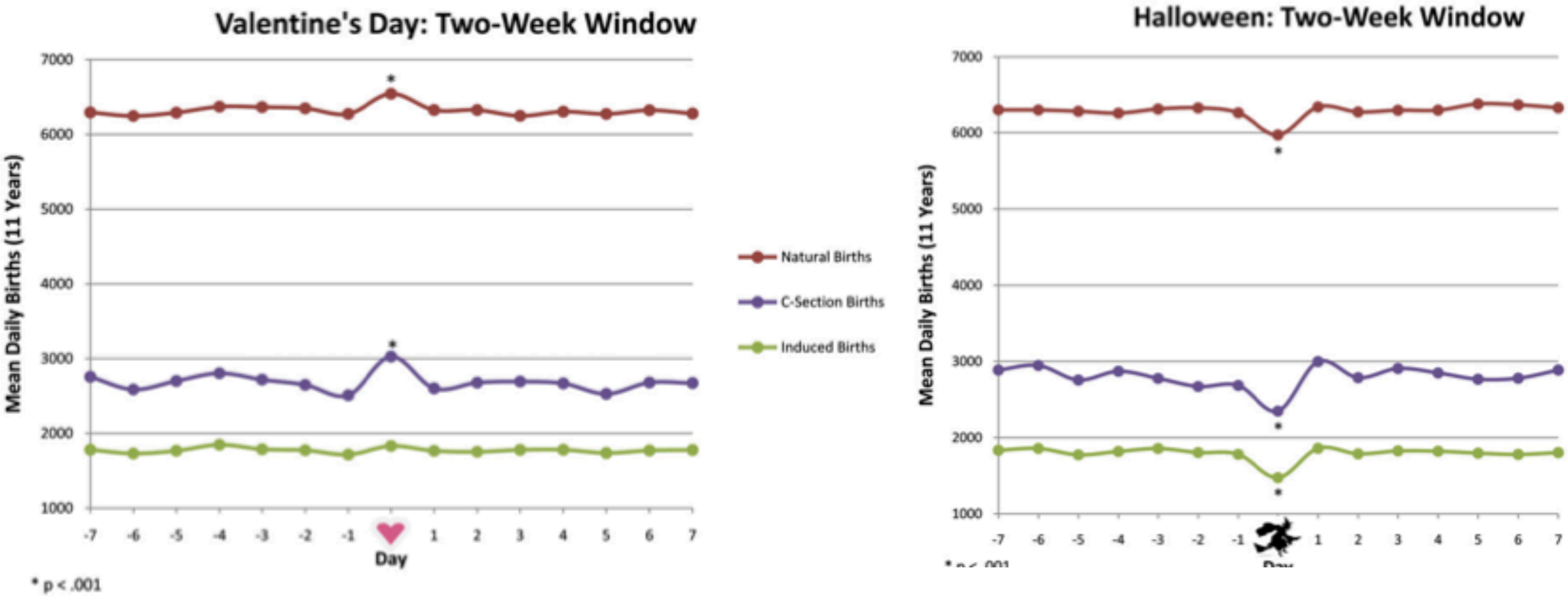
CDC birth data for the years 1969-1988

Processing: add by day sort descending, plot



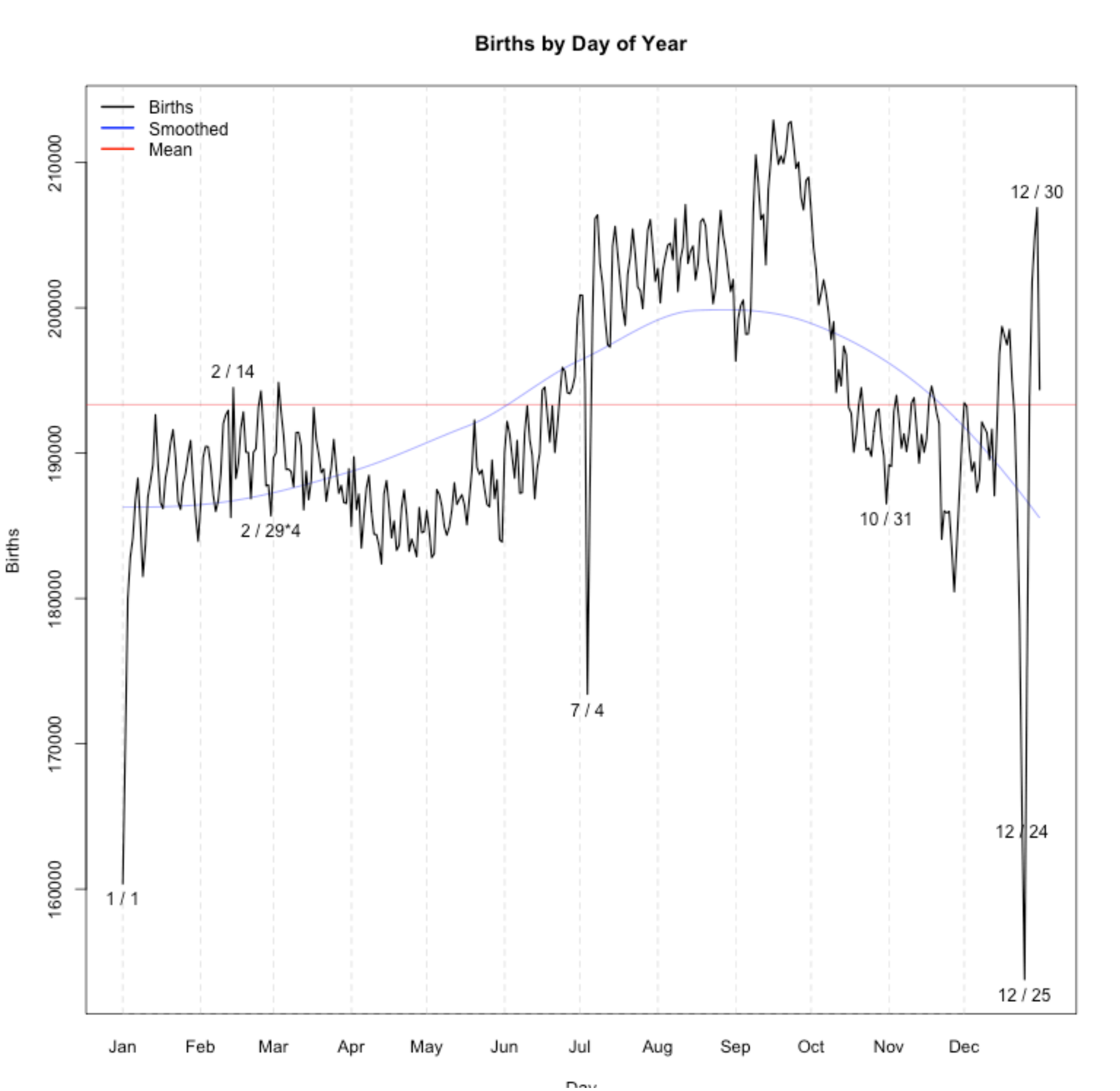
More Than No.s

- Preference for birthdays …
  - People love Valentines Day, and hate Halloween
  - Compute average for each day around date, plot



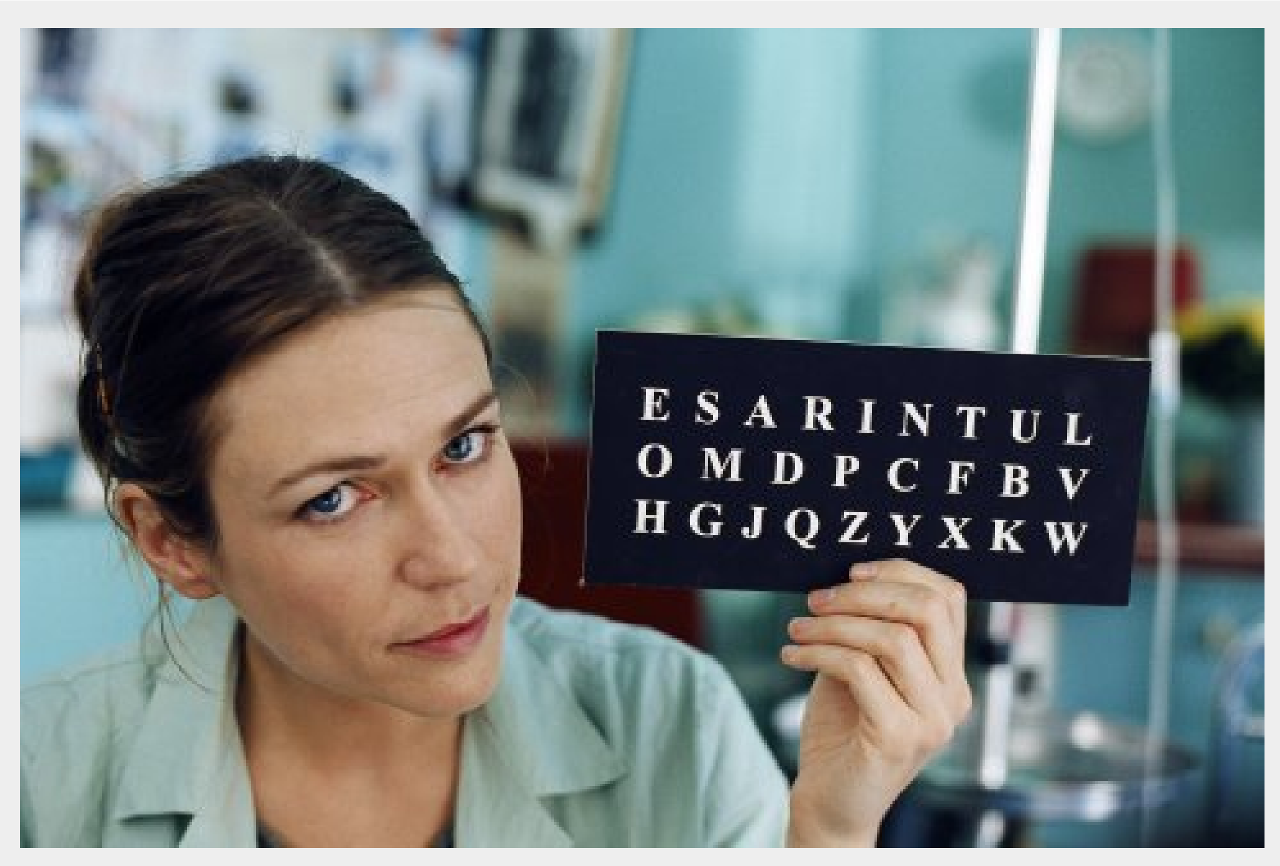
More Than No.s

- Plot raw data
- <Smooth>



Suppose You Have Lots of Text

- One thing you can do is figure out how often certain letters occur … good for “wink-comm”



Frequency Of Longer Sequences

- Counting the frequency of letters is more technically called “computing a 1-gram”
- More generally, an *n*-gram is counting up the frequency of sequences (of pretty much anything digital) of length *n*
- The 2-grams of this DNA: CGTTGACAACGT are: CG, GT, TT, TG, GA, AC, CA, AA, AC, CG, GT … so CG & GT occur twice, others just once
- The 2-grams of words in “To be or not to be” are: to-be, be-or, or-not, not-to, to-be
- Etc.

Google's List

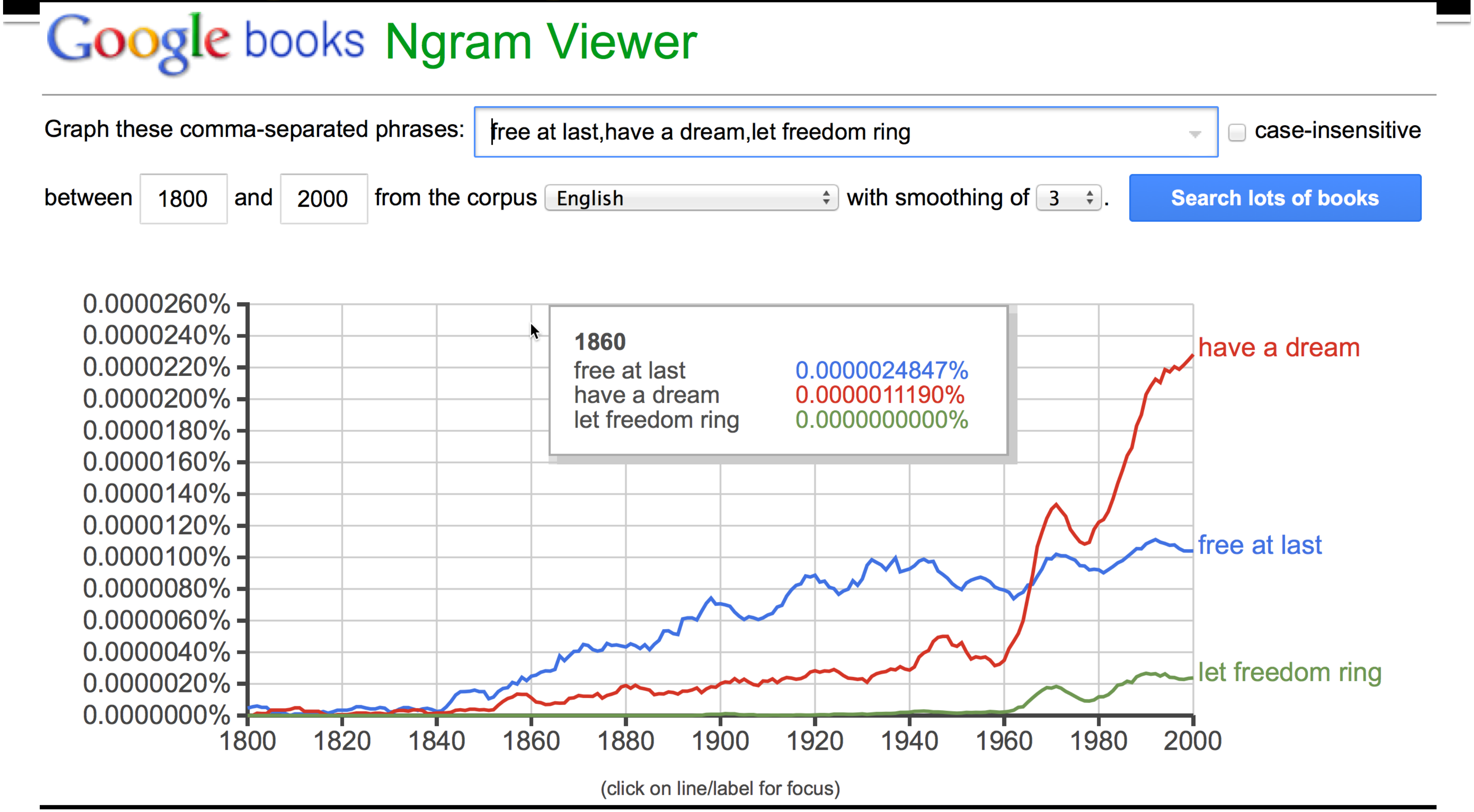
- Google has a lot of text, and has compiled the *n*-grams for tokens (i.e. words, non-blank letter sequences followed by punctuation or blank)

Number of tokens:	1,024,908,267,229
Number of sentences:	95,119,665,584
Number of unigrams:	13,588,391
Number of bigrams:	314,843,401
Number of trigrams:	977,069,902
Number of fourgrams:	1,313,818,354
Number of fivegrams:	1,176,470,663

What Are *n*-grams Good For

- Spelling correction software: Using an n-gram of letters, what’s wrong with “thniking”?
- Optical Character Recognition … if you have figured out “to be or not to <smudge>” you might use word 2-grams starting with “to”
- Google will just show you cool plots …

Google's n-gram Viewer



Graph these comma-separated phrases: free at last,have a dream,let freedom ring

□ case-insensitive

between 1800 and 2000 from the corpus English with smoothing of 3.

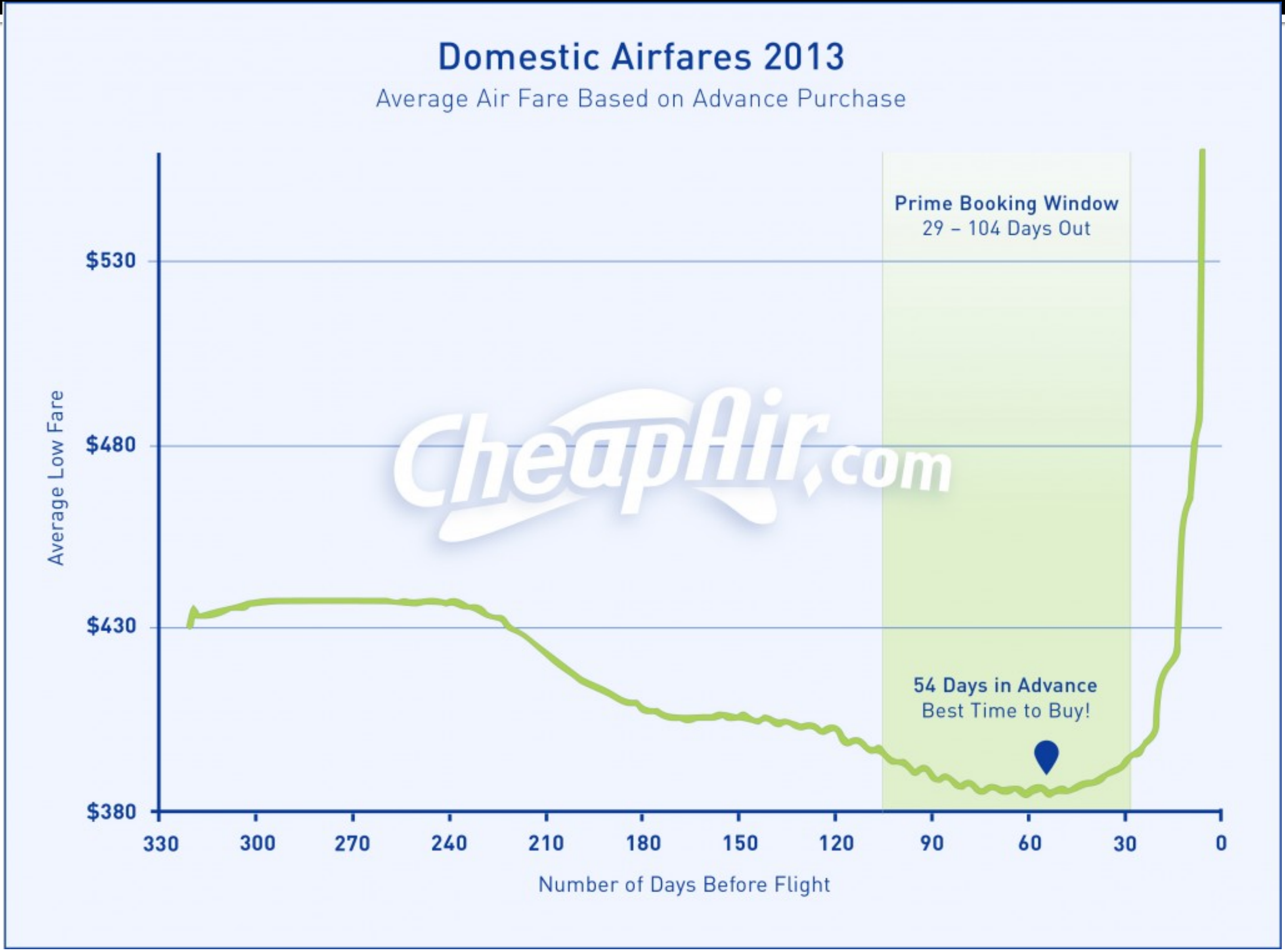
1860

free at last	0.0000024847%
have a dream	0.0000011190%
let freedom ring	0.0000000000%

Analyze Airline Prices

- CheapOair analyzed ticket price for 4 million airline trips in 2013 from 320 days before flight
- Fifty-four days before takeoff is, on average, when domestic airline tickets are at their absolute lowest price.
- Prime booking window: 104 - 29 days before your trip … usually within $10 of best price

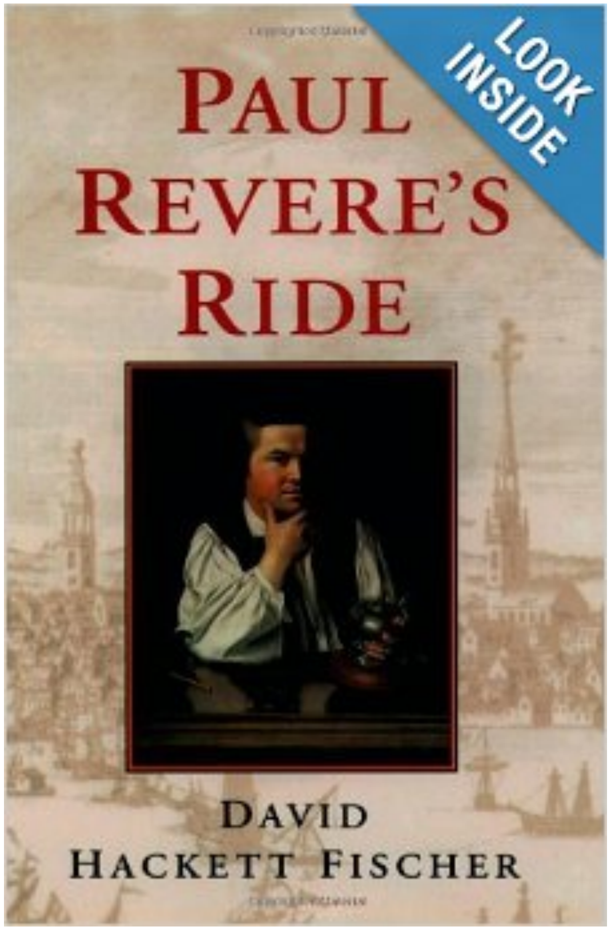
Information You Can Use



But There's Always Been Data

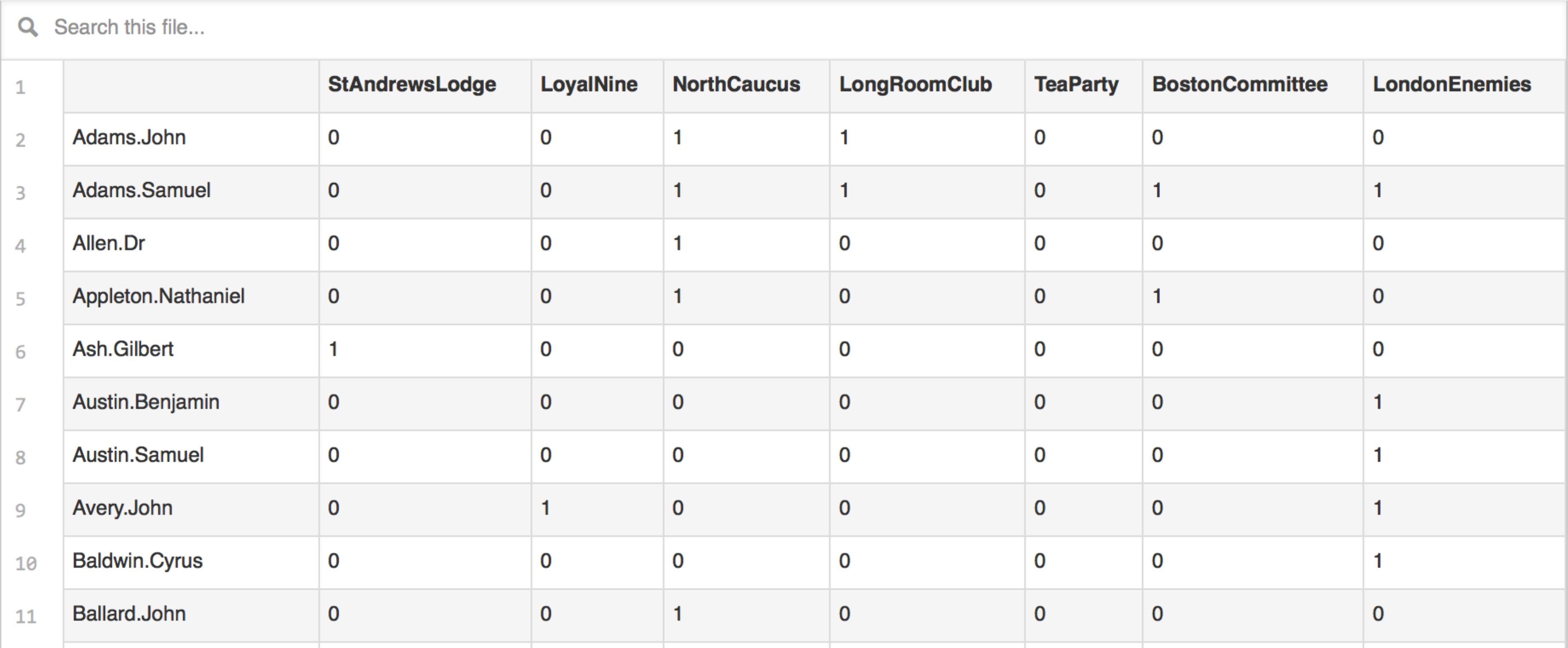
- Revolutionary War Boston Club membership as relayed in Fischer's Book
- Find it in the appendix … type it in

- Analysis by Kieran Healy http://kieranhealy.org/blog/archives/2013/06/09/using-metadata-to-find-paul-revere/



The Table Associations …

- A 254 x 7 table: colonist x organization



	StAndrewsLodge	LoyalNine	NorthCaucus	LongRoomClub	TeaParty	BostonCommittee	LondonEnemies
Adams.John	0	0	1	1	0	0	0
Adams.Samuel	0	0	1	1	0	1	1
Allen.Dr	0	0	1	0	0	0	0
Appleton.Nathaniel	0	0	1	0	0	1	0
Ash.Gilbert	1	0	0	0	0	0	0
Austin.Benjamin	0	0	0	0	0	0	1
Austin.Samuel	0	0	0	0	0	0	1
Avery.John	0	1	0	0	0	0	1
Baldwin.Cyrus	0	0	0	0	0	0	1
Ballard.John	0	0	1	0	0	0	0

- Organize such data with spreadsheet software

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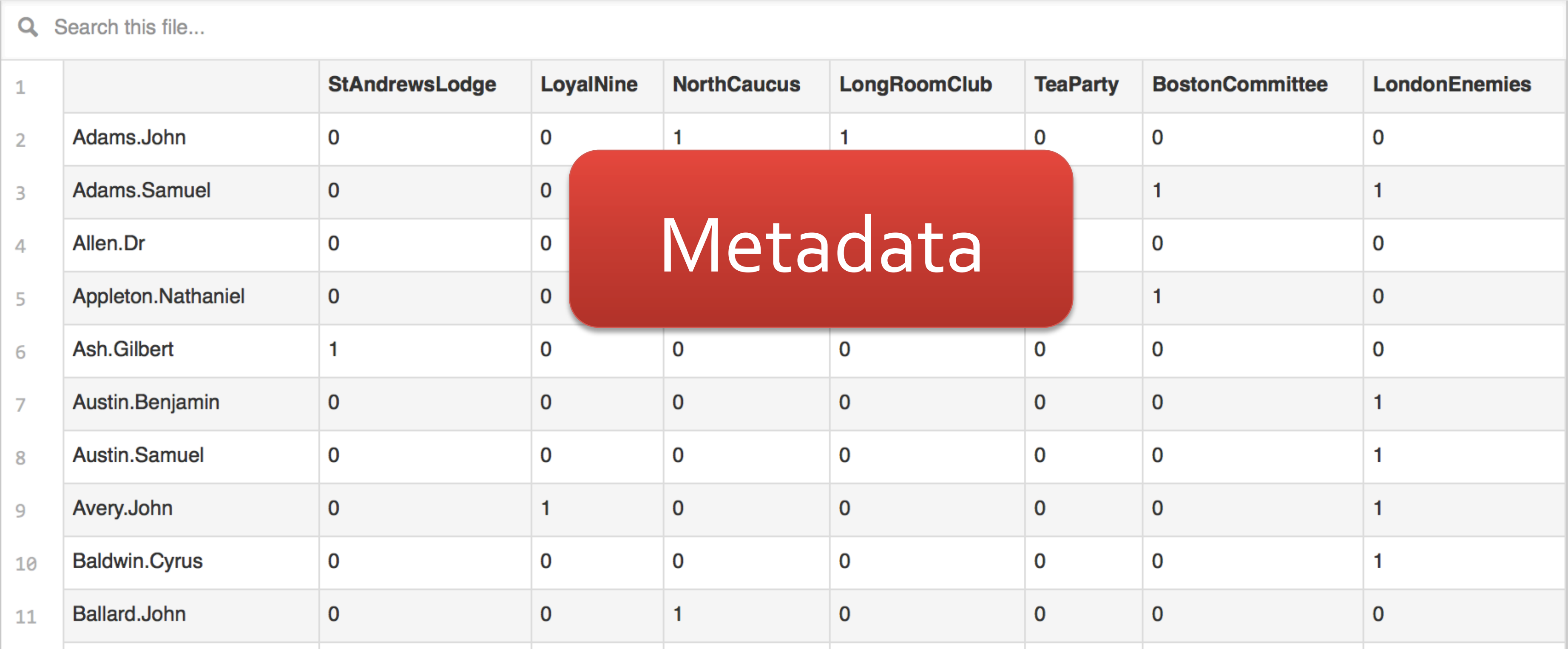
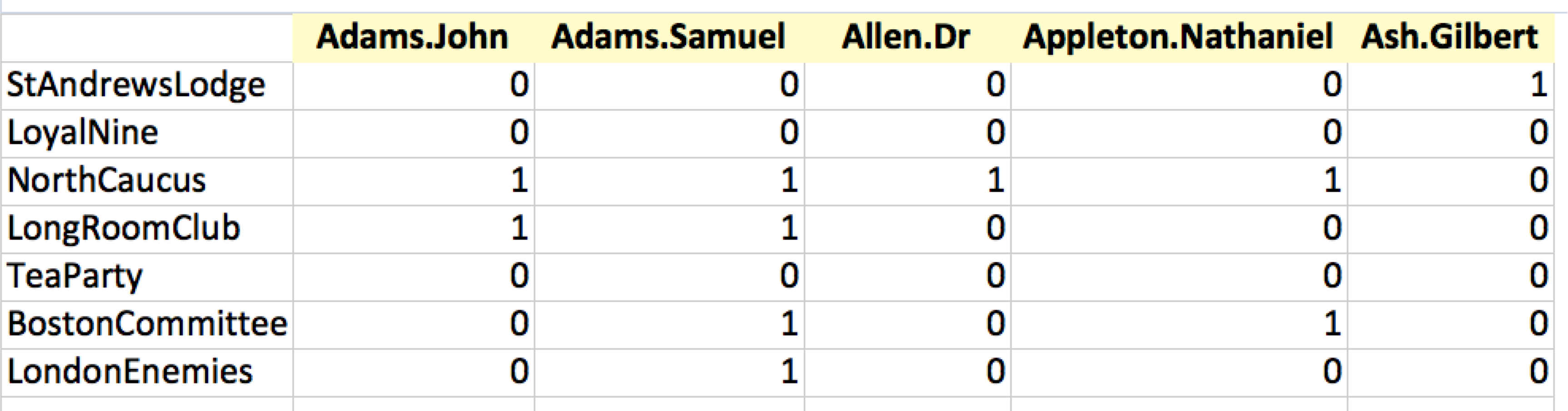


	StAndrewsLodge	LoyalNine	NorthCaucus	LongRoomClub	TeaParty	BostonCommittee	LondonEnemies
Adams.John	0	0	1	1	0	0	0
Adams.Samuel	0	0				1	1
Allen.Dr	0	0				0	0
Appleton.Nathaniel	0	0				1	0
Ash.Gilbert	1	0	0	0	0	0	0
Austin.Benjamin	0	0	0	0	0	0	1
Austin.Samuel	0	0	0	0	0	0	1
Avery.John	0	1	0	0	0	0	1
Baldwin.Cyrus	0	0	0	0	0	0	1
Ballard.John	0	0	1	0	0	0	0

Metadata

The Table of Colonists …

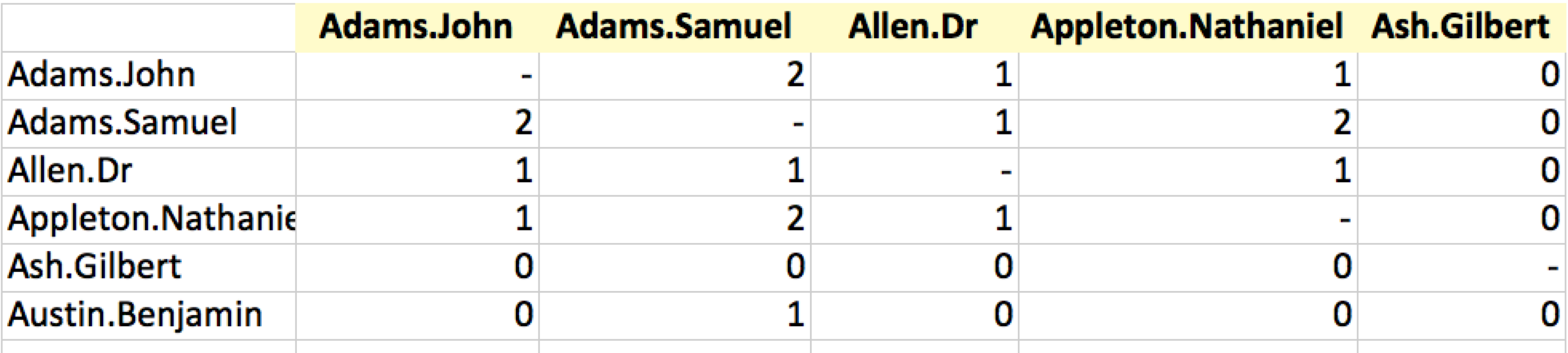
- Now, transpose the table – make columns rows, and rows columns
- A 7x254 table: organization x colonist



	Adams.John	Adams.Samuel	Allen.Dr	Appleton.Nathaniel	Ash.Gilbert
StAndrewsLodge	0	0	0	0	1
LoyalNine	0	0	0	0	0
NorthCaucus	1	1	1	1	0
LongRoomClub	1	1	0	0	0
TeaParty	0	0	0	0	0
BostonCommittee	0	1	0	1	0
LondonEnemies	0	1	0	0	0

Multiply The Two Matrices $A(A^T)$

- It produces a 254 x 254 table that shows for any pair of people (one in row and one in column) how many associations they have in common!

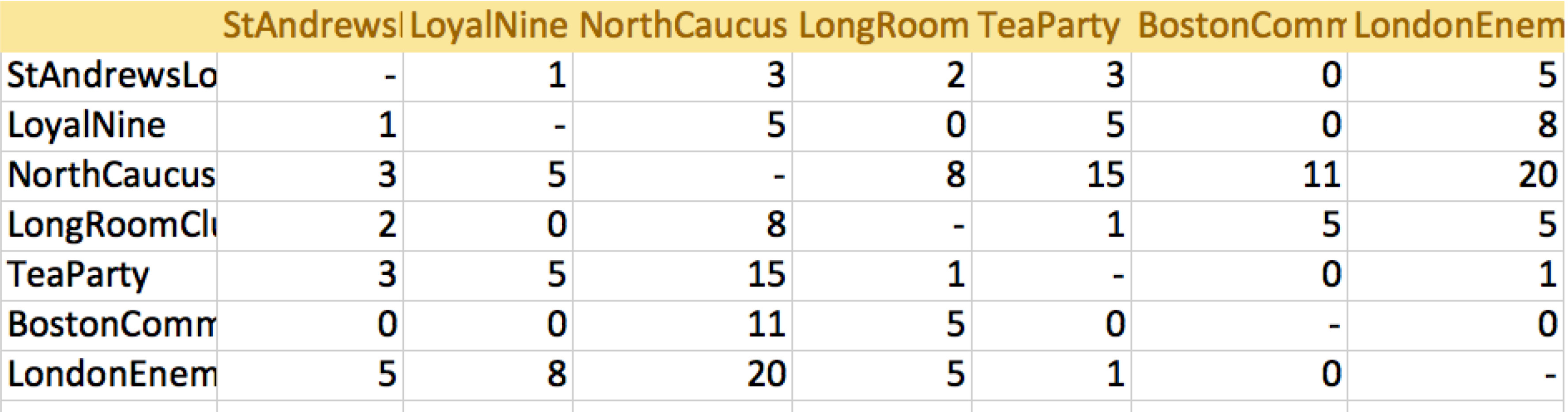


	Adams.John	Adams.Samuel	Allen.Dr	Appleton.Nathaniel	Ash.Gilbert
Adams.John	-	2	1	1	0
Adams.Samuel	2	-	1	2	0
Allen.Dr	1	1	-	1	0
Appleton.Nathanie	1	2	1	-	0
Ash.Gilbert	0	0	0	0	-
Austin.Benjamin	0	1	0	0	0

- The non-zero entries indicate pairs that might be collaborators

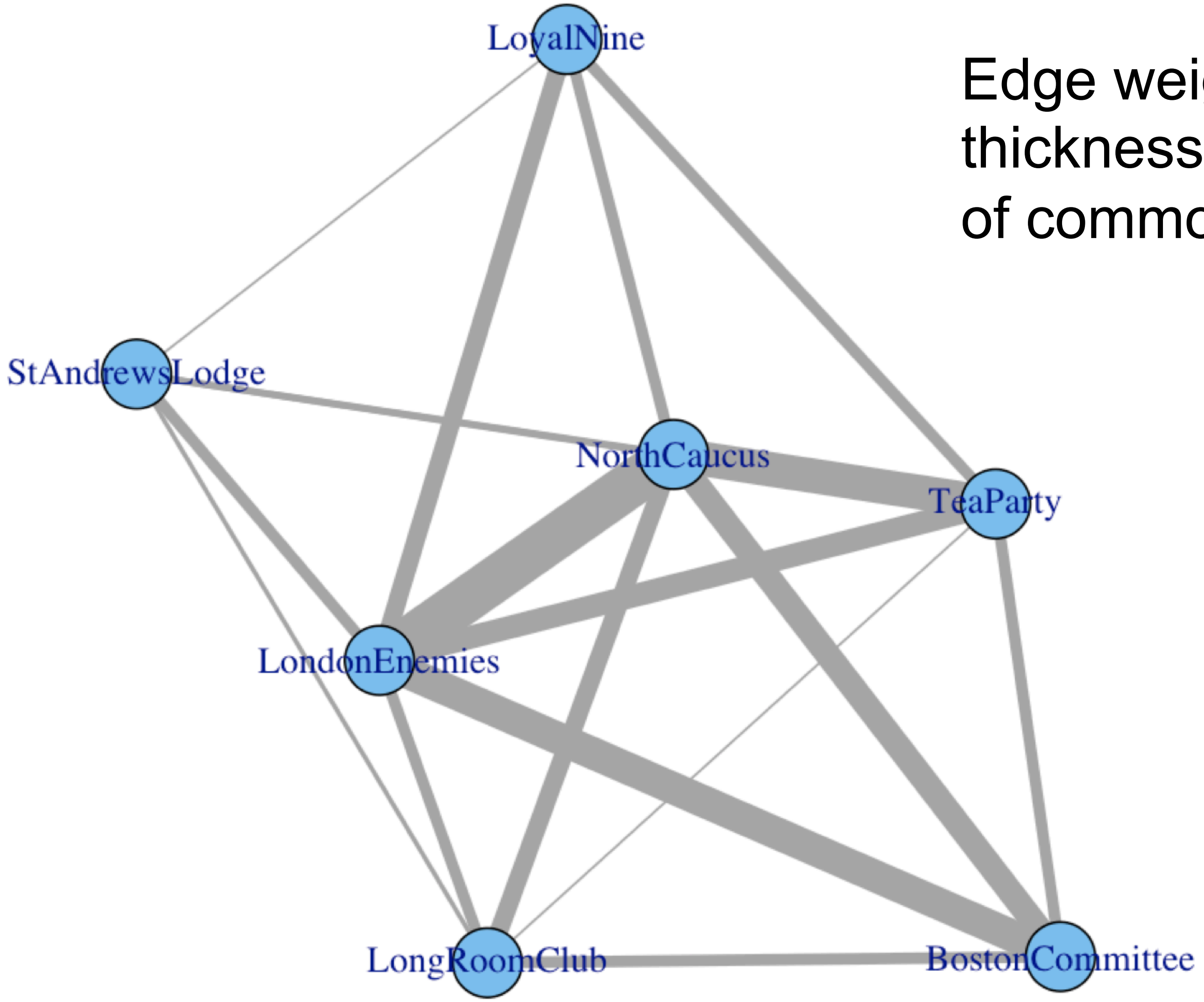
Multiply In Other Order $(A^T)A$

- Produces an organization x organization table saying how many members each pair (row, column) have in common



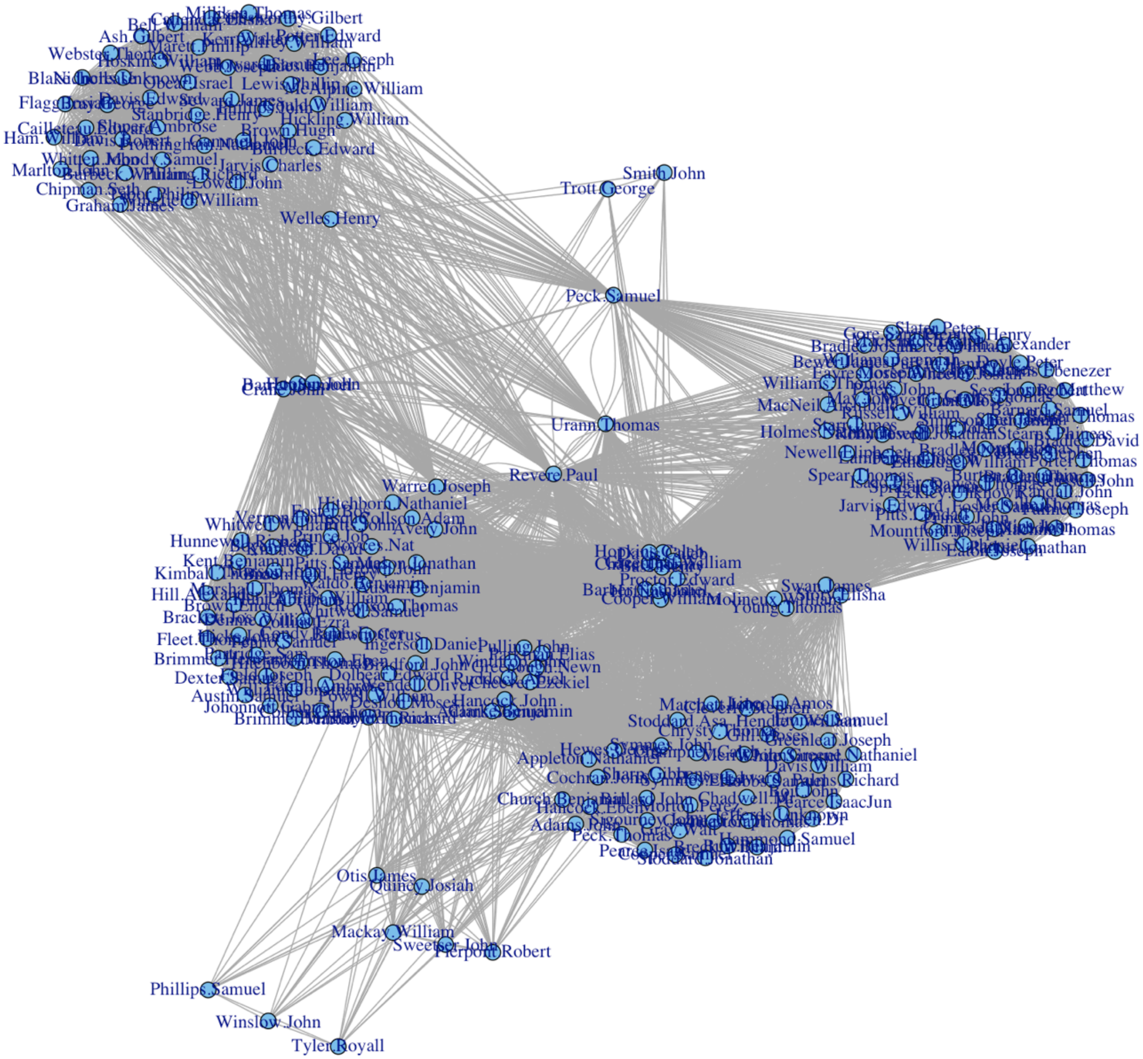
	StAndrewsl	LoyalNine	NorthCaucus	LongRoom	TeaParty	BostonComm	LondonEnem
StAndrewsLo	-	1	3	2	3	0	5
LoyalNine	1	-	5	0	5	0	8
NorthCaucus	3	5	-	8	15	11	20
LongRoomCl	2	0	8	-	1	5	5
TeaParty	3	5	15	1	-	0	1
BostonComm	0	0	11	5	0	-	0
LondonEnem	5	8	20	5	1	0	-

Diagram 7x7 Table for "A Visual"



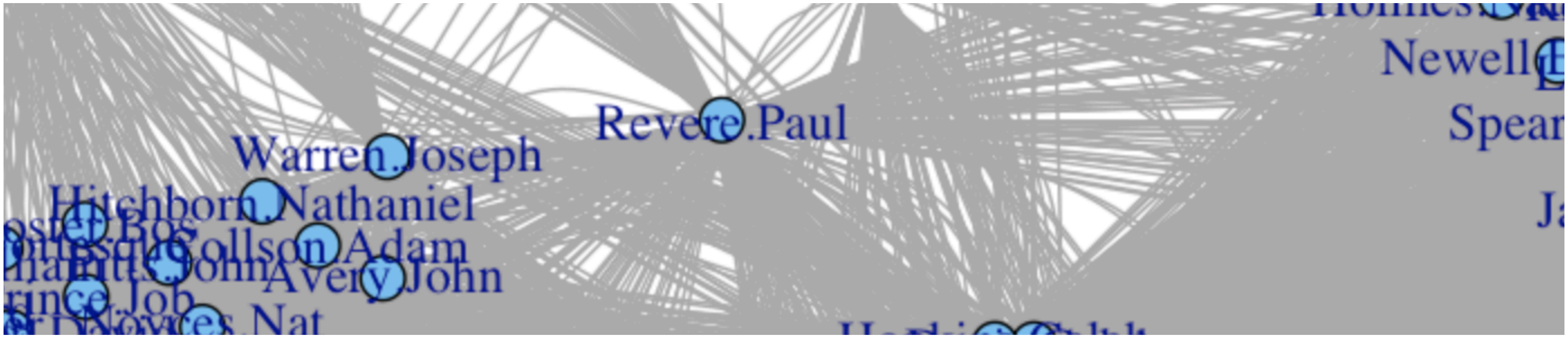
Edge weight (line thickness) is number of common members

Show Potential Collaborators



Zoom To See Who's Best Connected

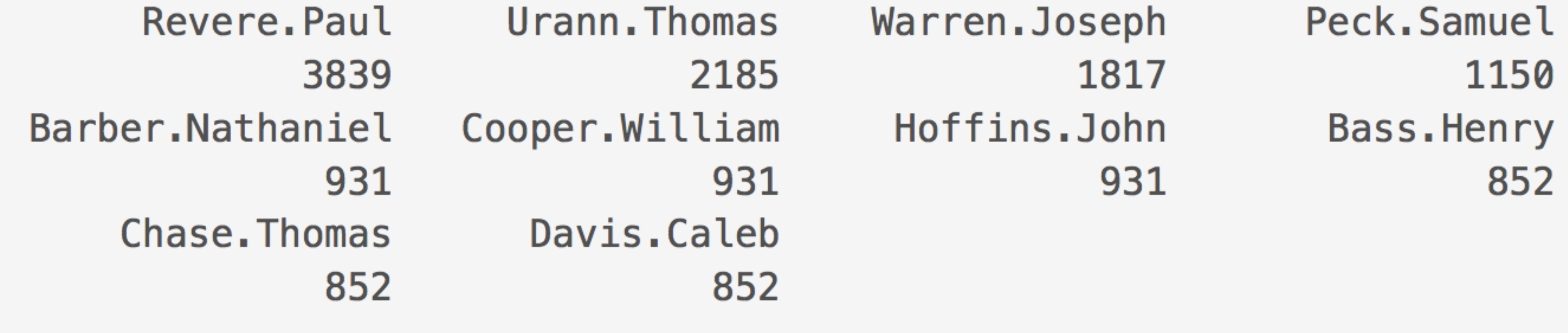
- A person of suspicion!



- Used membership metadata, performed normal analysis on it, identified key player

Betweeness Centrality

- How likely is that in the graph of who's connected to whom, a shortest path goes through a specific person – measure of connectedness



```
     Revere.Paul     Urann.Thomas    Warren.Joseph      Peck.Samuel
            3839             2185             1817             1150
Barber.Nathaniel   Cooper.William     Hoffins.John       Bass.Henry
             931              931              931              852
    Chase.Thomas      Davis.Caleb
             852              852
```

- Paul Revere is on 3839 shortest paths in the graph

Summary

- Data collections are everywhere
- Analyzing them can discover amazing facts
- Forms of analysis
  - Many techniques reveal interesting results with very primitive tools
  - We saw sorting, plotting, averaging, matrix product, centrality measures
  - Statistical software already exists
  - Mostly, the information can be "anonymized"

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How can big data be useful to you?