Advanced Data Visualization

CS 6965

Fall 2019

Prof. Bei Wang Phillips

University of Utah

Lecture 19

Foundations for Network Visualization

NV

Motivation for network visualization

Some fun reading: https://www.factslides.com/s-Facebook

Let’s begin with social networks….

Some fun reading: https://www.factslides.com/s-Facebook

https://www.youtube.com/watch?v=HMpWXQpogqI

https://www.youtube.com/watch?v=HMpWXQpogqI

Recent research at Facebook

February 2, 2018

StarSpace: Embed All The Things!

Conference on Artificial Intelligence (AAAI)

We present StarSpace, a general-purpose neural embedding model that can solve a wide variety of problems: labeling tasks such as text classification, ranking tasks such as information retrieval/web search, collaborative filtering-based or content-based recommendation, embedding of multi-relational graphs, and learning word, sentence or document level embeddings.

By: **Ledell Wu**, Adam Fisch, Sumit Chopra, Keith Adams, **Antoine Bordes**, **Jason Weston**

Areas: **Facebook AI Research (FAIR)**

Recent research at Facebook

August 28, 2017

Social Hash Partitioner: A Scalable Distributed Hypergraph Partitioner

Very Large Data Bases Conference (VLDB)

We design and implement a distributed algorithm for balanced k-way hypergraph partitioning that minimizes fanout, a fundamental hypergraph quantity also known as the communication volume and (k – 1)-cut metric, by optimizing a novel objective called probabilistic fanout. This choice allows a simple local search heuristic to achieve comparable solution quality to the best existing hypergraph partitioners.

By: Igor Kabiljo, **Brian Karrer**, Mayank Pundir, **Sergey Pupyrev**, Alon Shalita

Areas: **Data Science** **Systems & Networking**

https://research.fb.com/publications/

Recent research at Facebook

October 22, 2017

Grad-CAM: Visual Explanations from Deep Networks via Gradient-based Localization

International Conference on Computer Vision (ICCV)

We propose a technique for producing ‘visual explanations’ for decisions from a large class of Convolutional Neural Network (CNN)-based models, making them more transparent and explainable.

By: Ramprasaath R. Selvaraju, Michael Cogswell, Abhishek Das, Ramakrishna Vedantam, **Devi Parikh**, **Dhruv Batra**

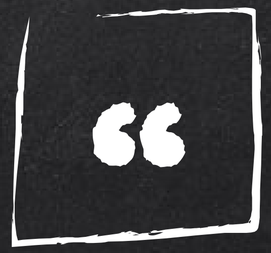
Areas: **Facebook AI Research (FAIR)**

How Facebook beat Myspace?

http://www.digitaltrends.com/social-media/former-myspace-ceo-reveals-what-facebook-did-right-to-dominate-social-media/
http://www.forbes.com/sites/adamhartung/2011/01/14/why-facebook-beat-myspace/#10a134077023

How Facebook Beat Myspace?

- Same audience, social media revolution
- The failure of professional management (by News Corps.) v.s White Space management (letting the marketplace decide)
- What do users want? User-driven apps and functionalities



Facebook was able to overtake MySpace because Facebook “perfected” the social networking concept, whereas MySpace just introduced people to it.

– Mike Jones, formerly the head of MySpace.

Read more: http://www.digitaltrends.com/social-media/former-myspace-ceo-reveals-what-facebook-did-right-to-dominate-social-media/#ixzz44yAwZx91

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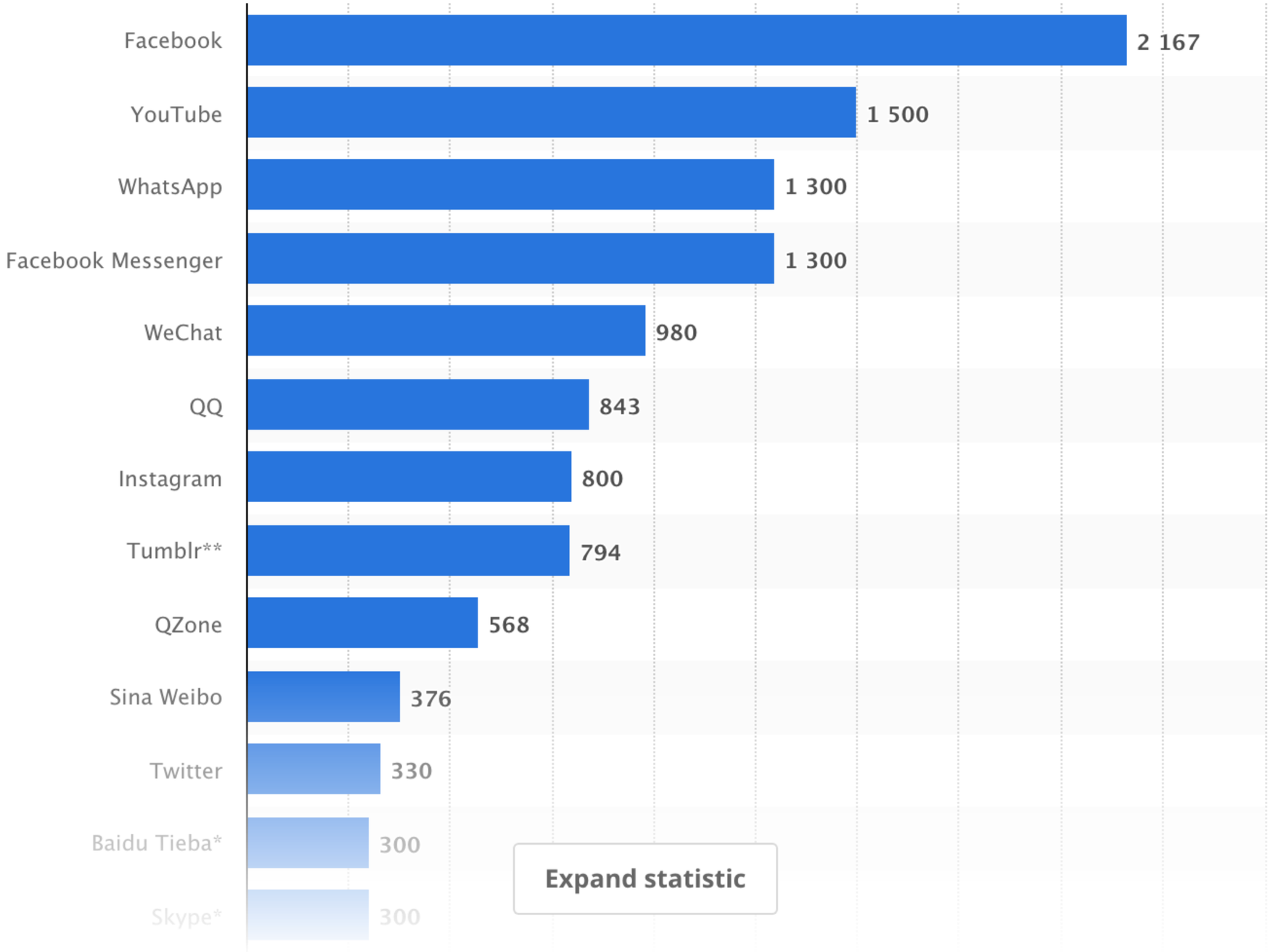
How Facebook Beat Myspace?

- MySpace put up barriers to user enjoyment by forcing members to use anonymous pseudonyms in place of their real identities.
- As of March 2015, Facebook has 1.44 billion users a month, Myspace has 50 million
- Which ones are the leading social networks worldwide?



https://www.statista.com/statistics/272014/global-social-networks-ranked-by-number-of-users/

Here are the top 20 most-used social networking sites and apps in the world, 2019

1. Facebook: 2.27 billion
2. YouTube: 1.9 billion
3. WhatsApp: 1.5 billion
4. Facebook Messenger: 1.3 billion
5. WeChat: 1.08 billion
6. Instagram: 1 billion
7. QQ: 803 million
8. QZone: 531 million
9. Douyin / Tik Tok: 500 million
10. Sina Weibo: 446 million
11. Reddit: 330 million
12. Twitter: 326 million
13. Douban: 320 million
14. LinkedIn: 303 million
15. Baidu Tieba: 300 million
16. Skype: 300 million
17. Snapchat: 287 million
18. Viber: 260 million
19. Pinterest: 250 million
20. LINE: 194 million

https://ceoworld.biz/2019/03/03/the-20-top-most-used-social-networking-sites-and-apps-in-the-world-2019/

Has google+ really died?

- The number of truly active users on Google+ is significantly less than 1% of the total 2.2 billion Google users, according to a study published on April 14, 2015
- On April 24, 2014, Alexia Tsotsis and Matthew Panzarino wrote in TechCrunch that "Google+ Is Walking Dead."
- Google has consistently failed to get to heart of social. People prefer Facebook to Google+, fundamentally because Google's approach to social isn't fun.
- A head-on challenge to Facebook was inevitably unsuccessful.
- Failure to offer something genuinely new
- Further reading: http://www.forbes.com/sites/stevedenning/2015/04/23/has-google-really-died/#34f09f5b16e9 http://www.forbes.com/sites/stevedenning/2015/04/17/five-reasons-why-google-died/#6542a4dd33c0

Has google+ really died?

- Nov, 2015. Major redesign of Google+
- Communities and Collections functionality: narrow the service's scope into interest-based networking

2017

https://blumint.co/stop-thinking-google-plus-dead

Future of Facebook?

- Virtual reality: Gear VR; Oculus Rift.
- AI
- Further reading: http://www.businessinsider.com/mark-zuckerberg-interview-with-axel-springer-ceo-mathias-doepfner-2016-2

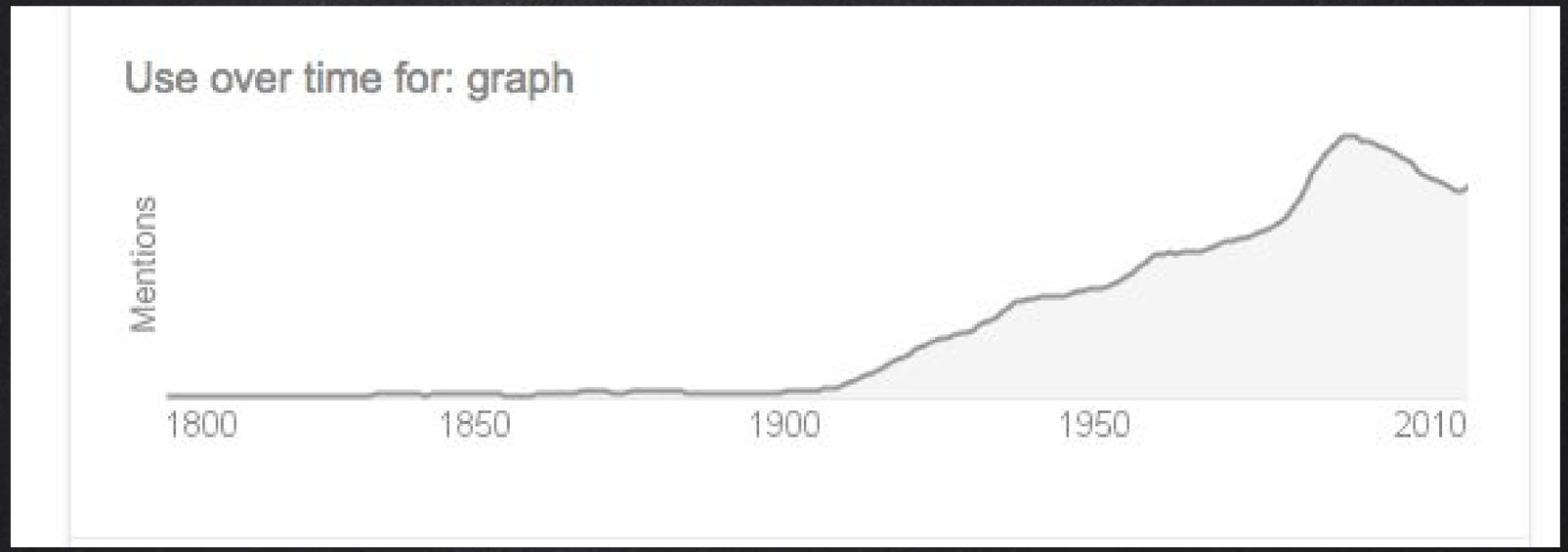
Mark Zuckerberg: "Virtual Reality is the next platform"

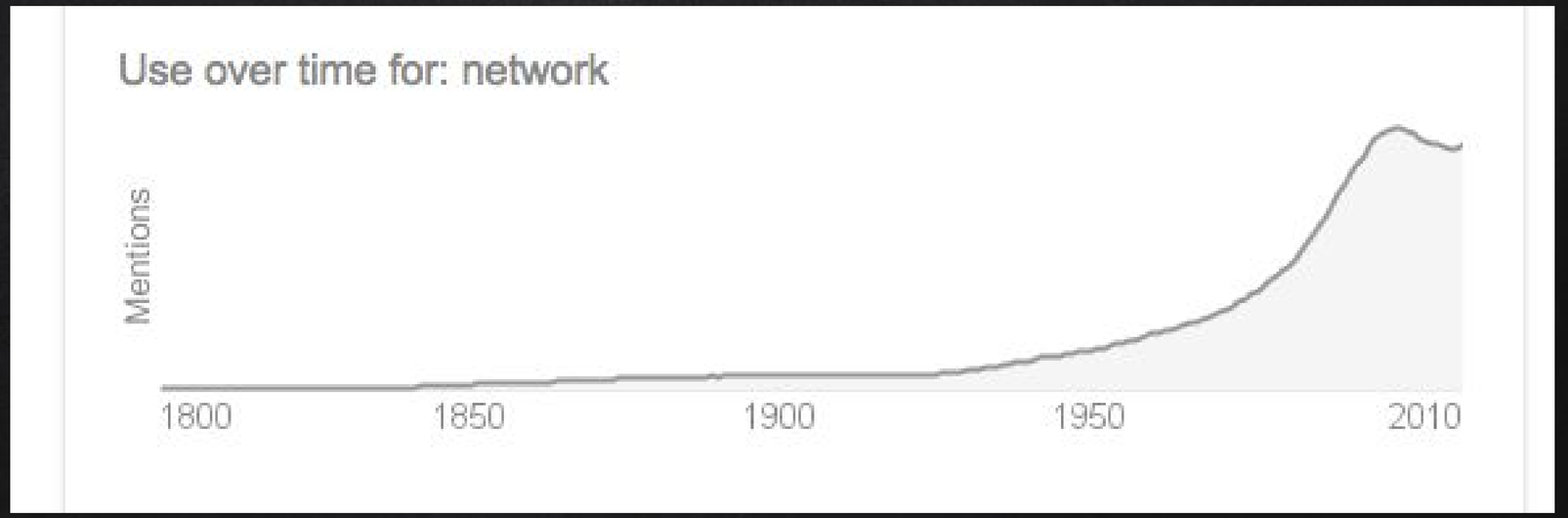
https://www.youtube.com/watch?v=8vQggbWtjOo

https://www.youtube.com/watch?v=YuIgyKLPt3s

Imaging new form of data available with advancement with social networks!

Graph Analysis


Use over time for: graph
Mentions
1800
1850
1900
1950
2010


Use over time for: network
Mentions
1800
1850
1900
1950
2010

Graphs and networks

What is a graph?

Graph may refer to:

In **information science**:

- Chart, a graphical representation of data also called a "graph"
- Infographic, a graph intermixing data and visual or textual information

In **mathematics**:

- Graph (discrete mathematics), a set of vertices and edges
  - Graph theory, the study of such graphs
- Graph of a function

In **computer science**:

- Graph (abstract data type), an abstract data type representing relationships or connections
- Conceptual graph, a model for knowledge representation and reasoning

https://en.wikipedia.org/wiki/Graph

What is a Network?
Network science?
Complex network?

Network science is an academic field which studies complex networks such as telecommunication networks, computer networks, biological networks, cognitive and semantic networks, and social networks, considering distinct elements or actors represented by *nodes* (or *vertices*) and the connections between the elements or actors as *links* (or *edges*). The field draws on theories and methods including graph theory from mathematics, statistical mechanics from physics, data mining and information visualization from computer science, inferential modeling from statistics, and social structure from sociology. The United States National Research Council defines network science as "the study of network representations of physical, biological, and social phenomena leading to predictive models of these phenomena."[1]

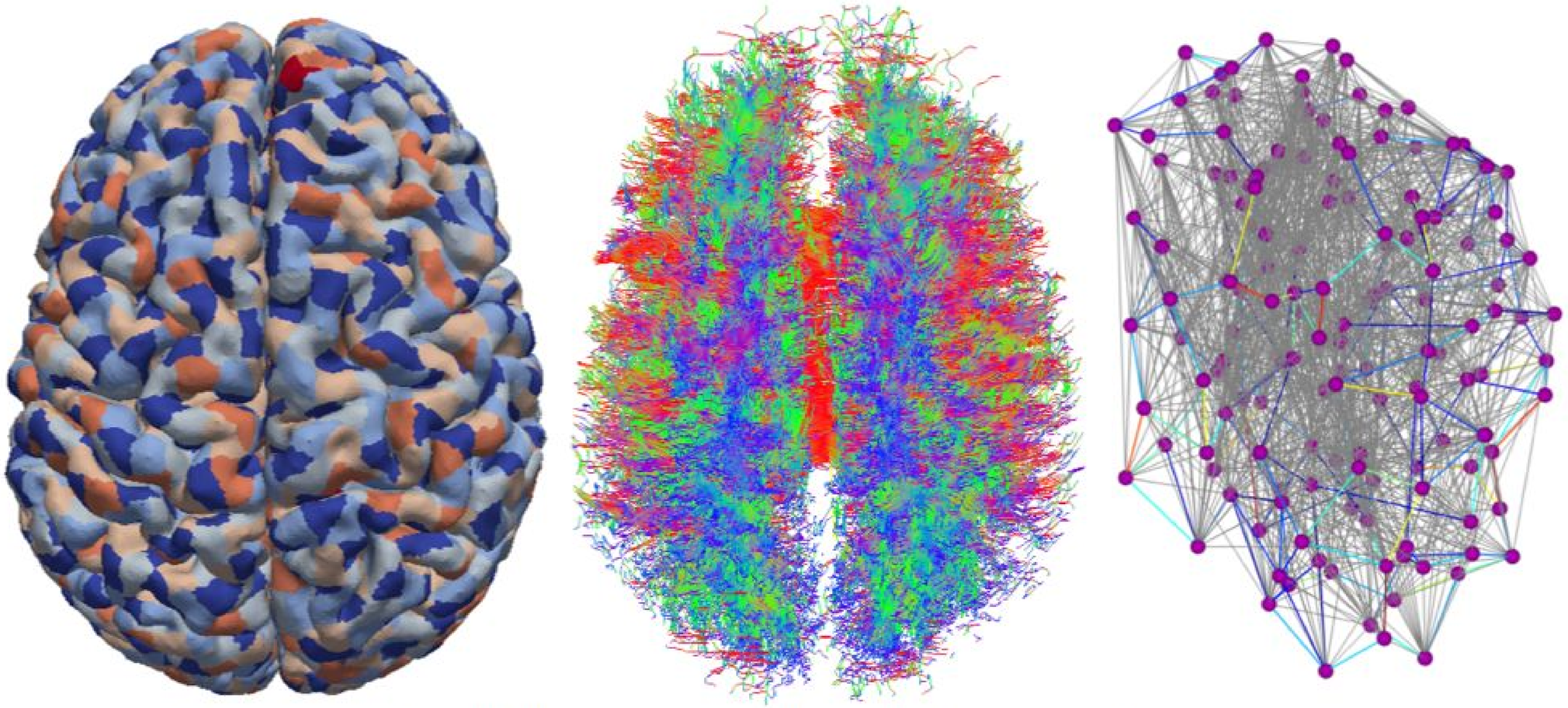
https://en.wikipedia.org/wiki/Network_science

In the context of network theory, a **complex network** is a graph (network) with non-trivial topological features—features that do not occur in simple networks such as lattices or random graphs but often occur in graphs modelling of real systems. The study of complex networks is a young and active area of scientific research (since 2000) inspired largely by the empirical study of real-world networks such as computer networks, technological networks, brain networks and social networks.

https://en.wikipedia.org/wiki/Complex_network

Brain Networks

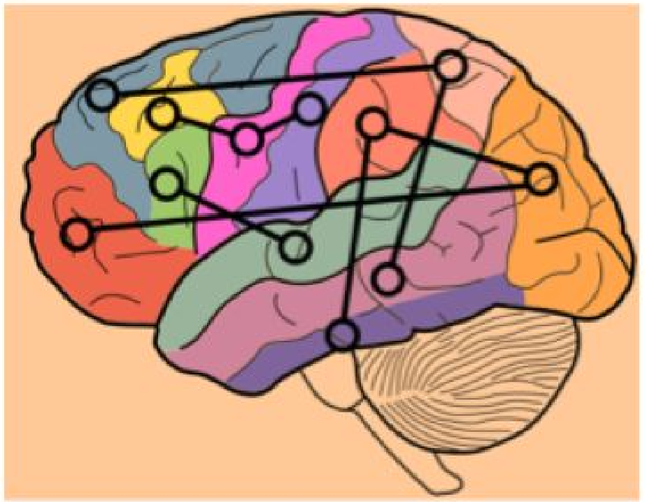
- Structurally connectivity and functional connectivity
- Subject comparisons in clinical studies: medical prognosis, brain disorders, e.g., autism, Alzheimers disease, and schizophrenia.



Left: cortical surface. Middle: brain structural networks. Right: brain functional networks.
[Hammond, Gur, Johnson, 2013]

Brain network analysis in predicting autism severity

- Correlation between brain functional networks and ADOS using kernel partial least squares regression (kPLS)
- ADOS: Autism Diagnostic Observation Schedule scores
- Regress network topology against behavioral phenotypes
- Adding topological features to raw fMRI correlations



functional network

behavior

[Wong, Palande, **Wang**, Zielinski, Anderson, Fletcher (ISBI), 2016.]

Social Networks

Social network Analysis

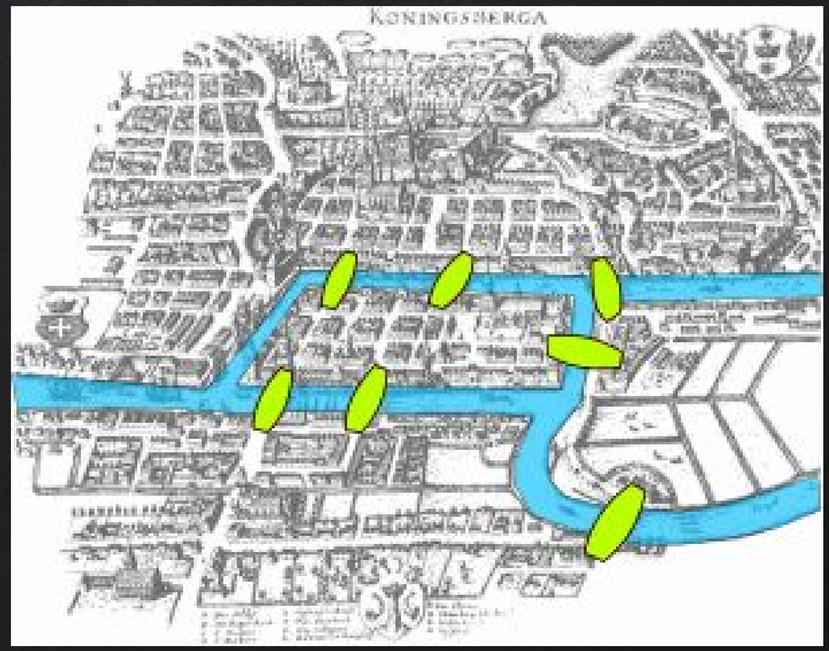
- A **social network** is a social structure made up of a set of social actors (such as individuals or organizations), sets of dyadic ties, and other social interactions between actors.
- Provides a set of methods for analyzing the structure of whole social entities as well as a variety of theories explaining the patterns observed in these structures.
- Identifies local and global patterns, locate influential entities, and examine network dynamics.
- E.g. who is the most influential person in Facebook? Hint: Obama and Huckabee in 2012 according to some statistics

Back to the basics

Graph Theory

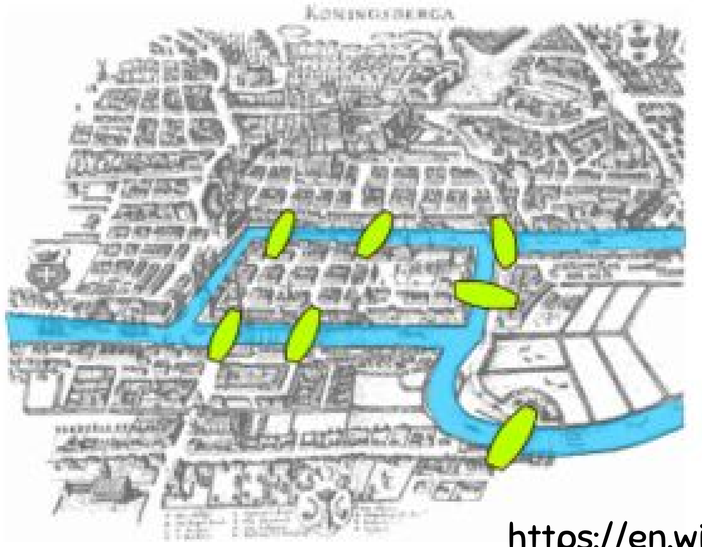
Graph theory

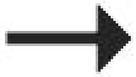
- The mathematical study of properties and applications of graphs.

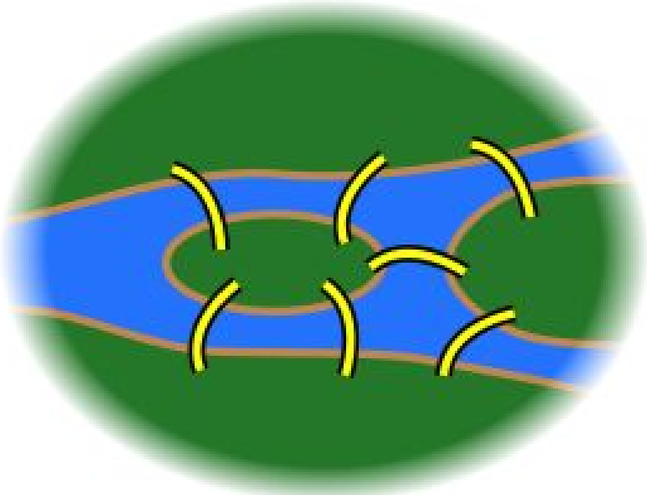


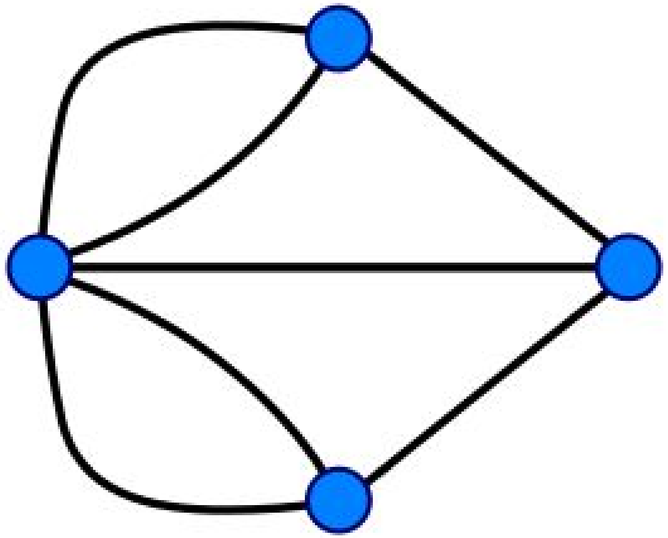
Seven Bridges of Königsberg

- Devise a walk through the city that would cross each bridge once and only once
- Abstraction
  - Every land mass is a vertex
  - Every bridge is an edge
  - The # of bridges touching a land mass (except starting point) must be *even*









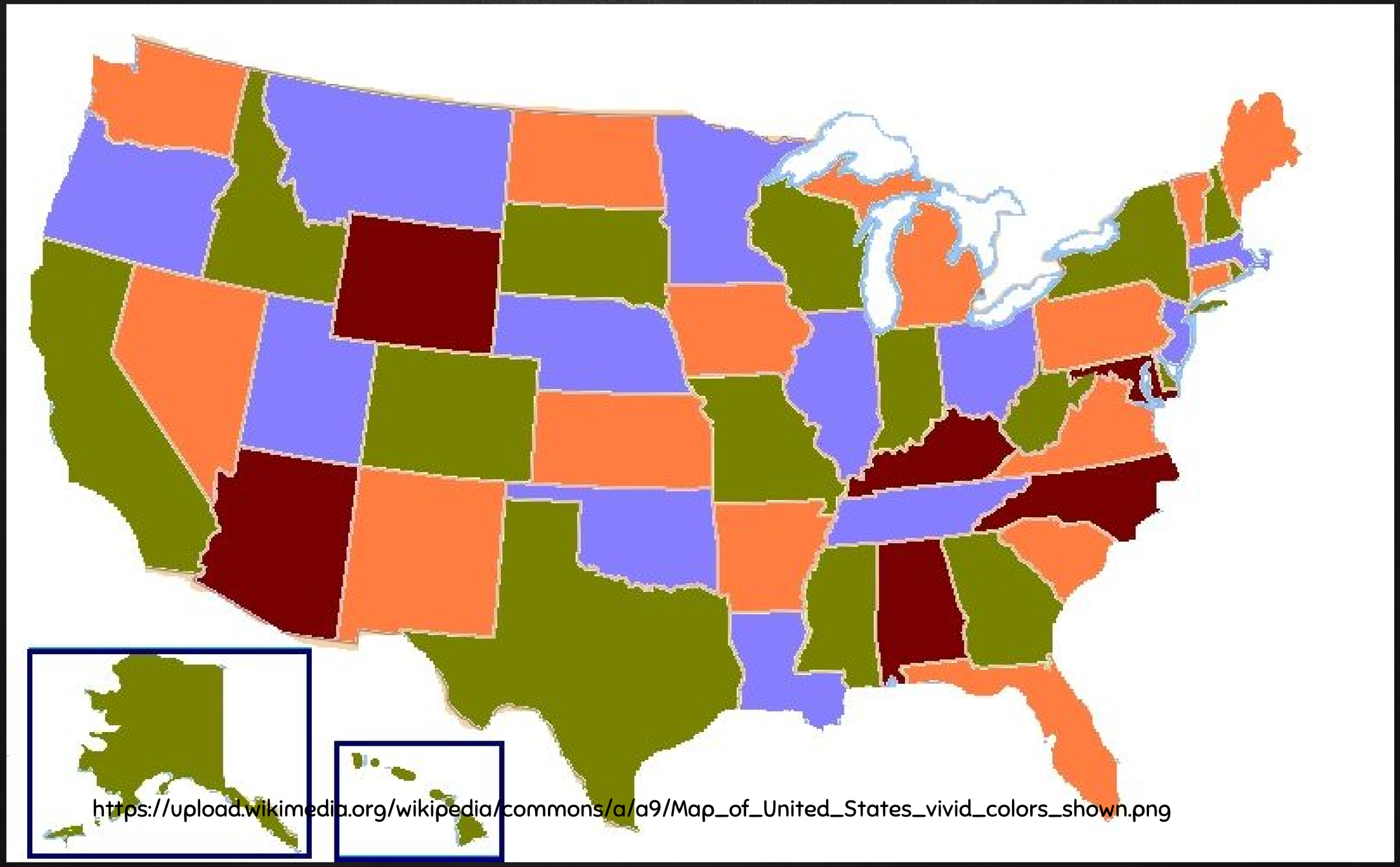
https://en.wikipedia.org/wiki/Seven_Bridges_of_K%C3%B6nigsberg

Four coloring problem

Is it true that any map drawn in the plane may have its regions colored with four colors, in such a way that any two regions having a common border have different colors?

- Francis Guthrie, 1852
- Proven in 1976 by Appel and Haken: first major theorem to be proved using a computer
- Simpler proof using computer: 1997
- 2005, Gonthier with general purpose theorem proving software

https://en.wikipedia.org/wiki/Four_color_theorem



https://upload.wikimedia.org/wikipedia/commons/a/a9/Map_of_United_States_vivid_colors_shown.png

Basic Concepts in Graph Theory

Easy Reading: https://en.wikipedia.org/wiki/Graph_(discrete_mathematics)

Some Basic Notions

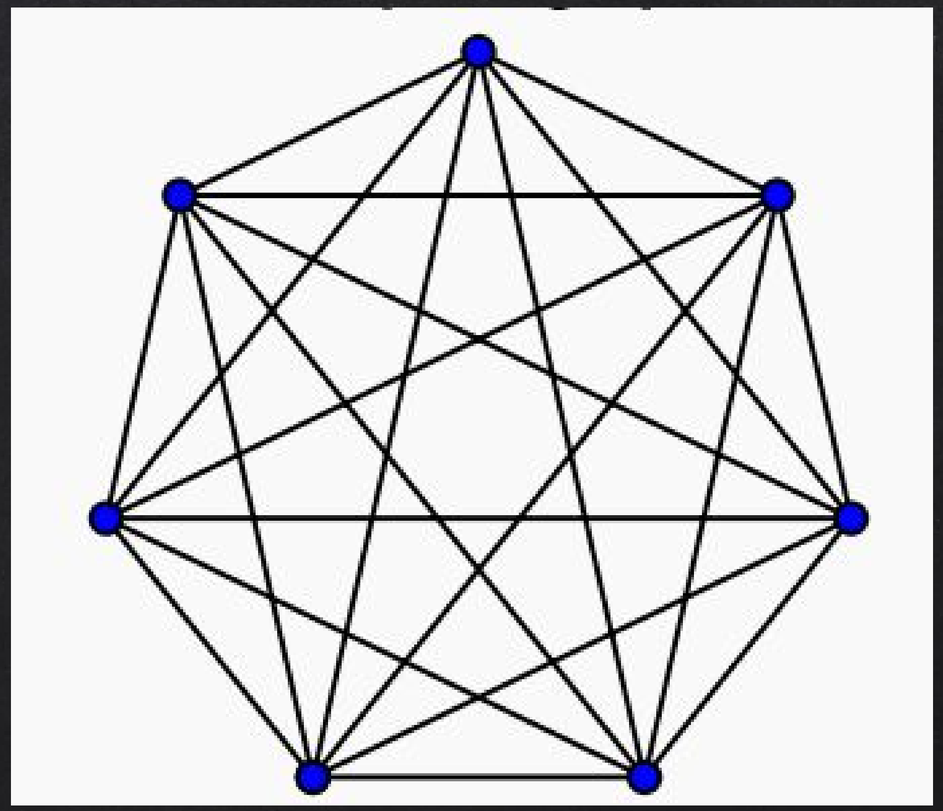
- Type of graphs:
  - directed, undirected
  - Weighted, unweighted

https://www.youtube.com/watch?v=82zIRaRUsaY

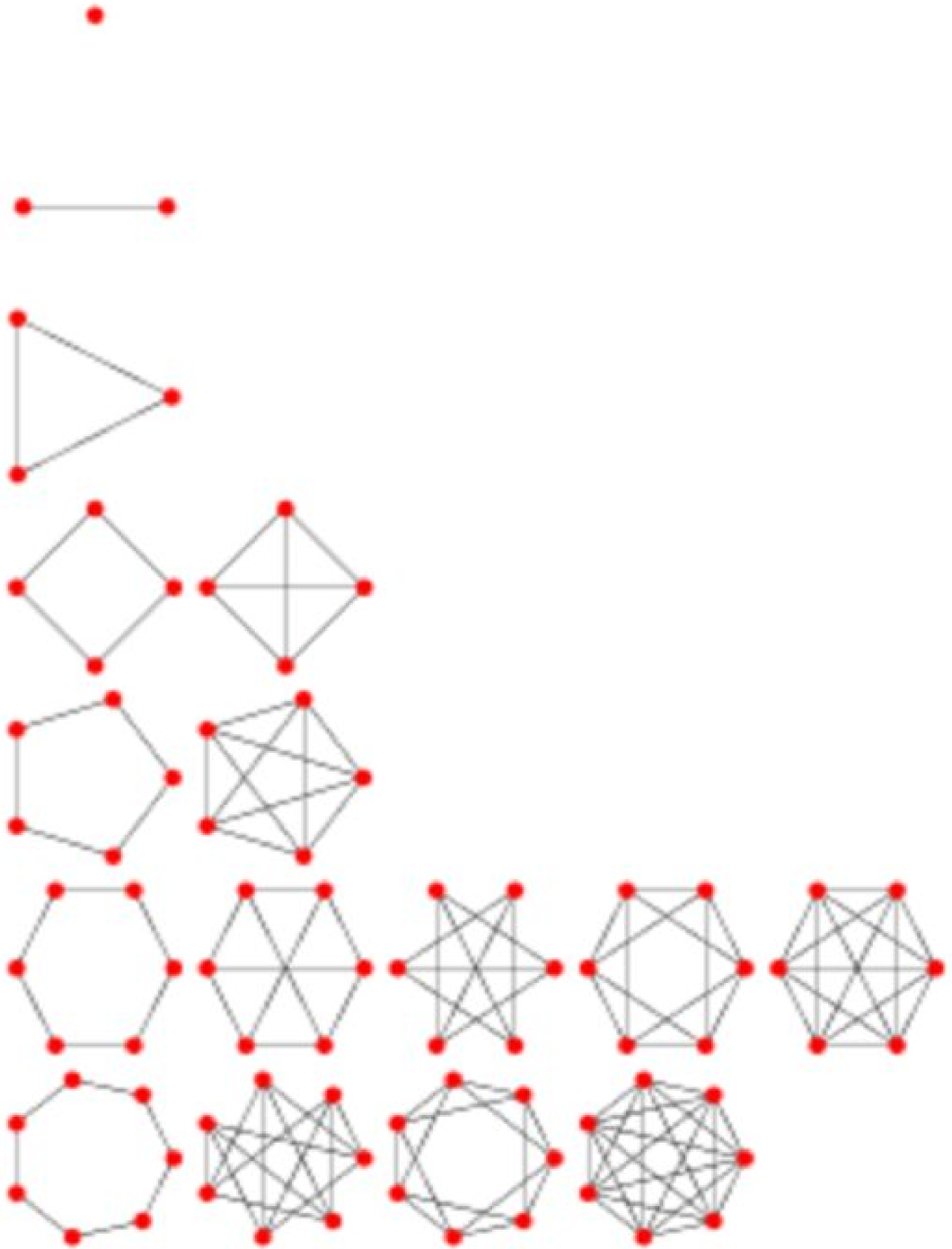
Describe graphs by structure

Slides inspired by: http://www.slideshare.net/BenjaminBengfort/social-network-analysis-with-python?from_action=save

Complete Graphs



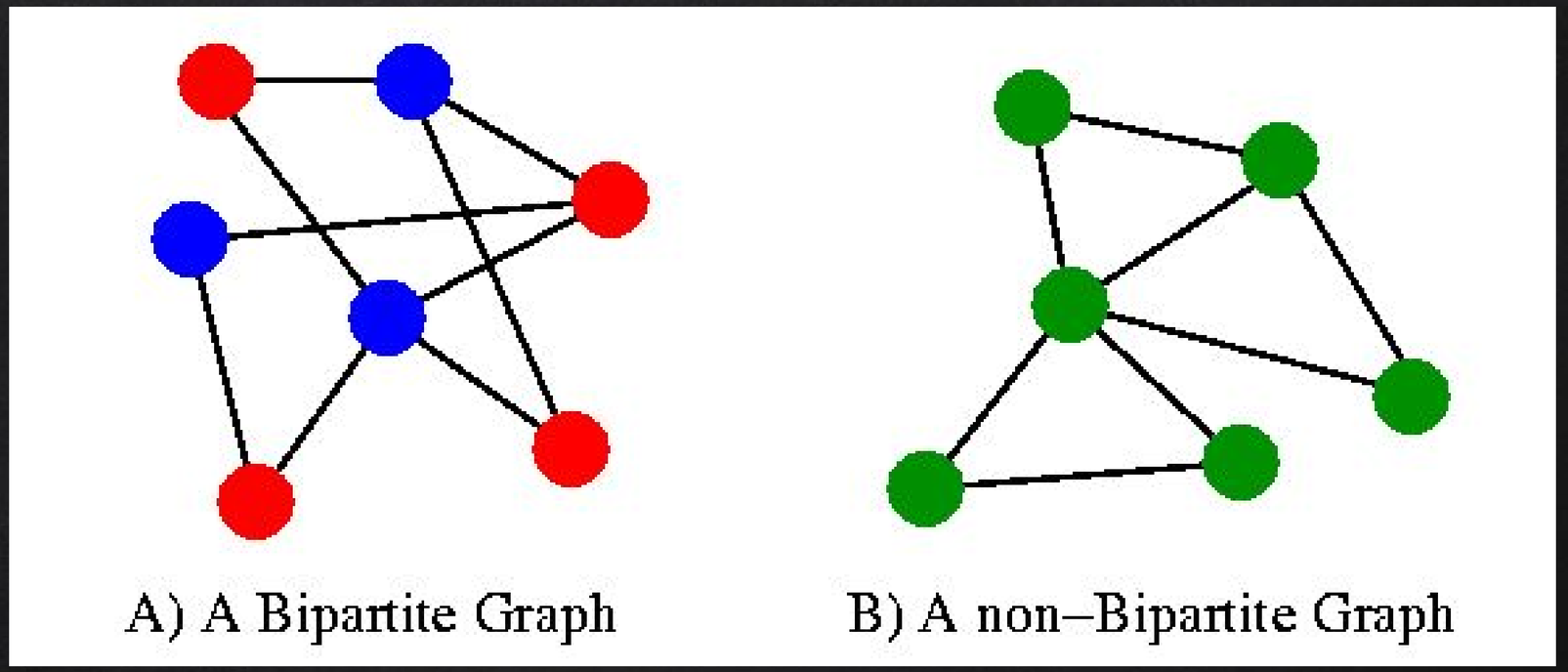
Read more: https://en.wikipedia.org/wiki/Complete_graph



Regular Graphs

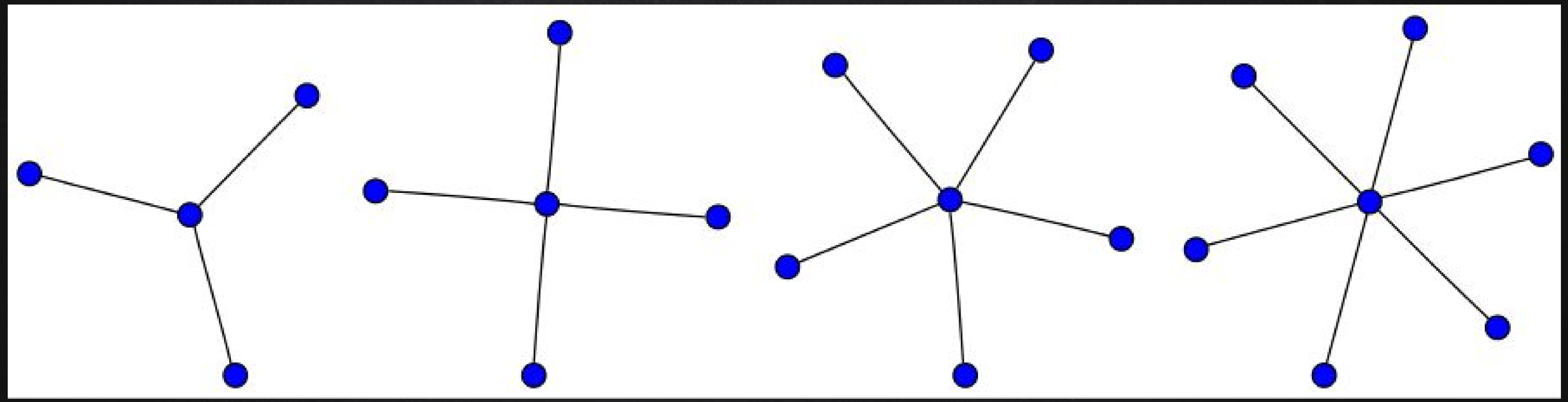
Read more: http://mathworld.wolfram.com/RegularGraph.html
https://en.wikipedia.org/wiki/Regular_graph

Bipartite Graphs



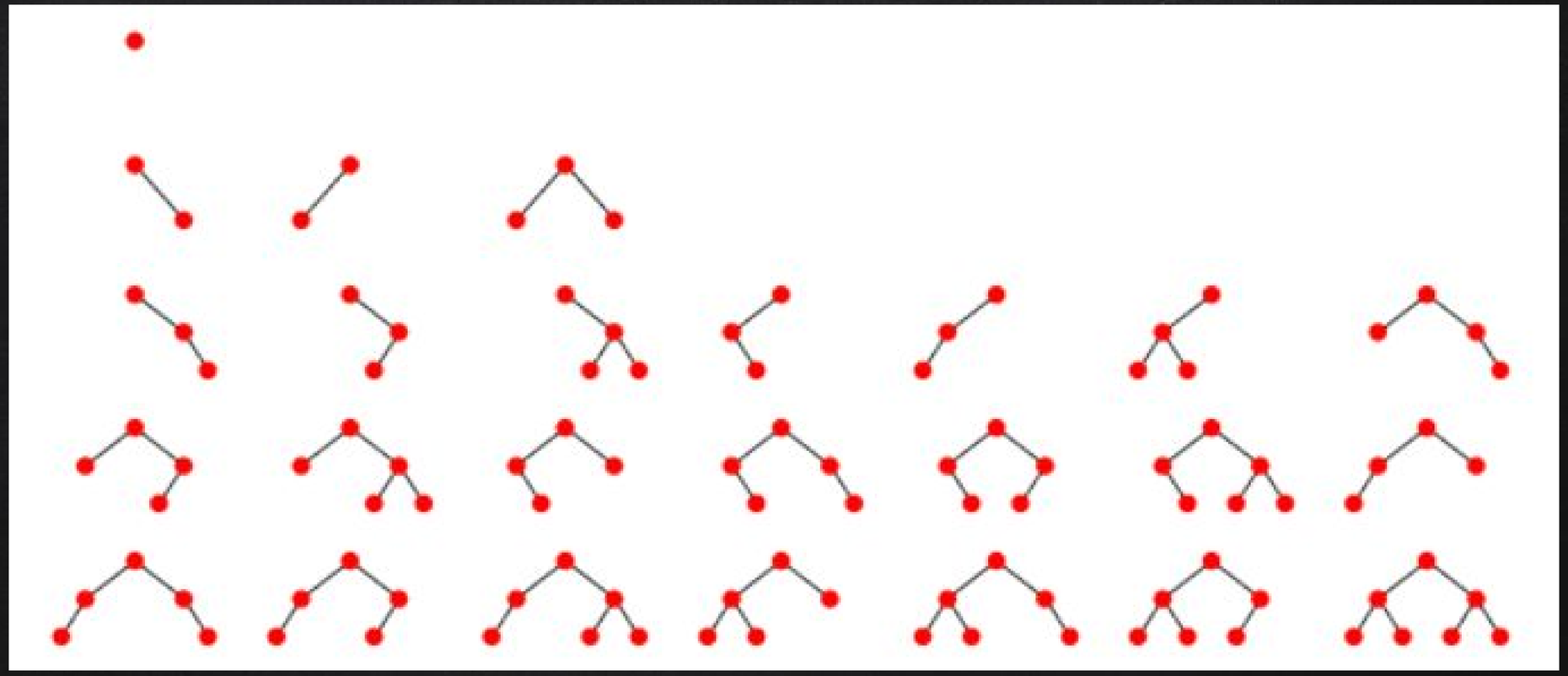
Credit: http://users.dickinson.edu/~braught/courses/cs332s03/projects/project2.html

Star Graphs



Credit: https://en.wikipedia.org/wiki/Star_(graph_theory)

Tree



Binary Trees
Credit:
http://mathworld.wolfram.com/BinaryTree.html

Some graph algorithms

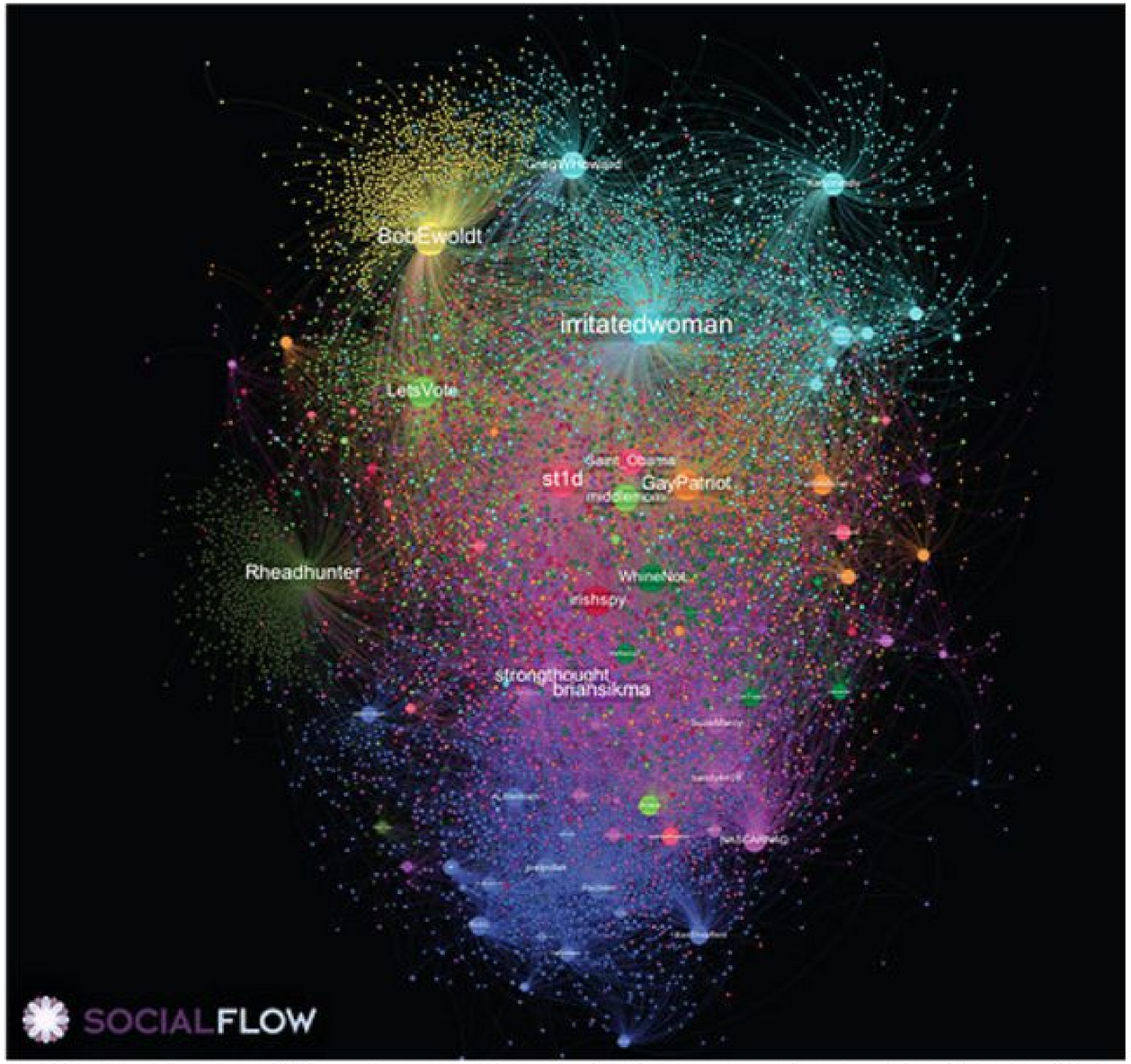
Examples of graph algorithms

- Traversal (shortest distance, network flow)
- Search (optimal node, subgraph)
- Clustering (group sets of nodes)

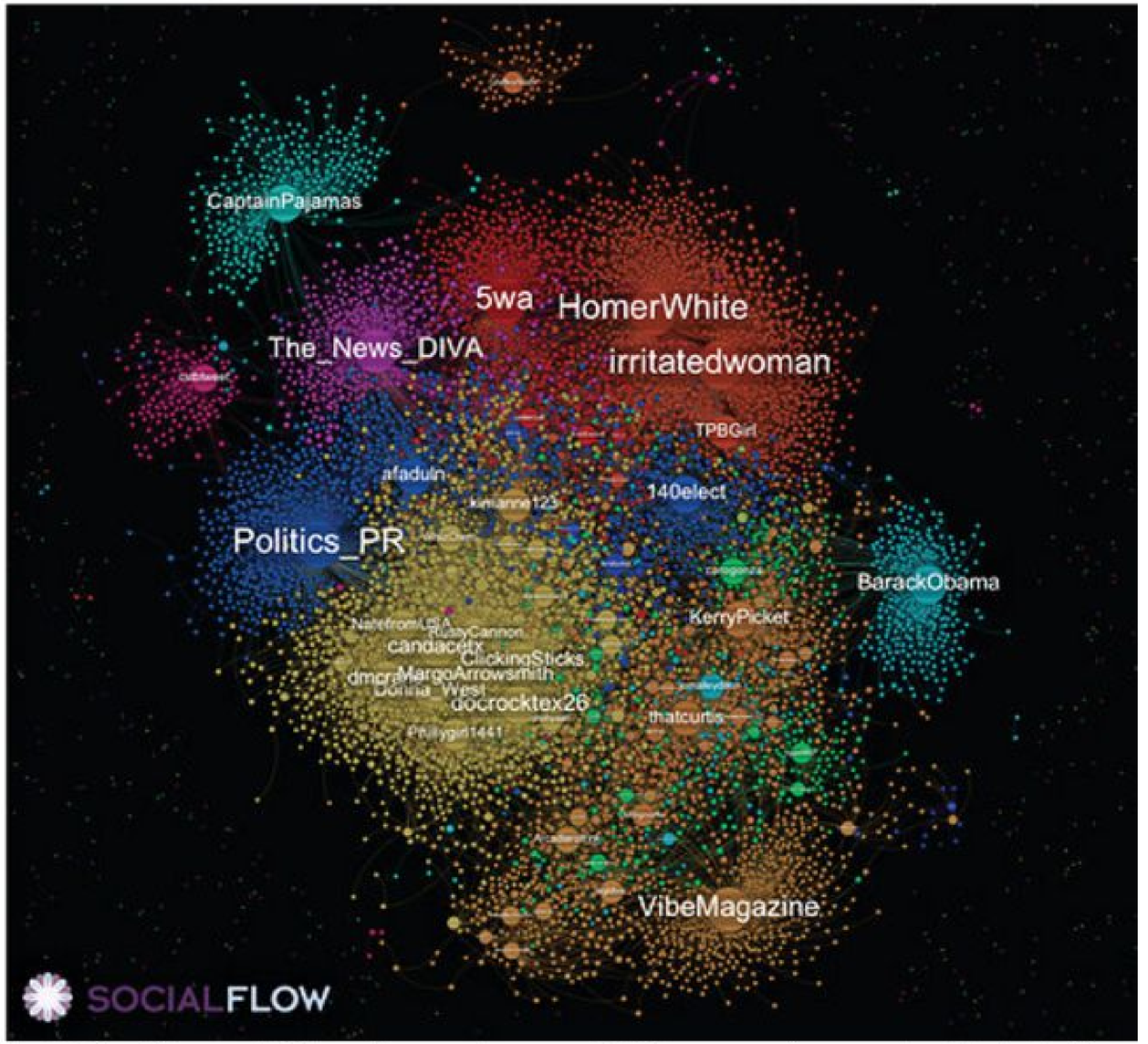
Further reading:

https://en.wikipedia.org/wiki/Category:Graph_algorithms

Why are graphs important?



Social FlowThe most followed accounts among Twitter users who gave the debate to Paul Ryan.

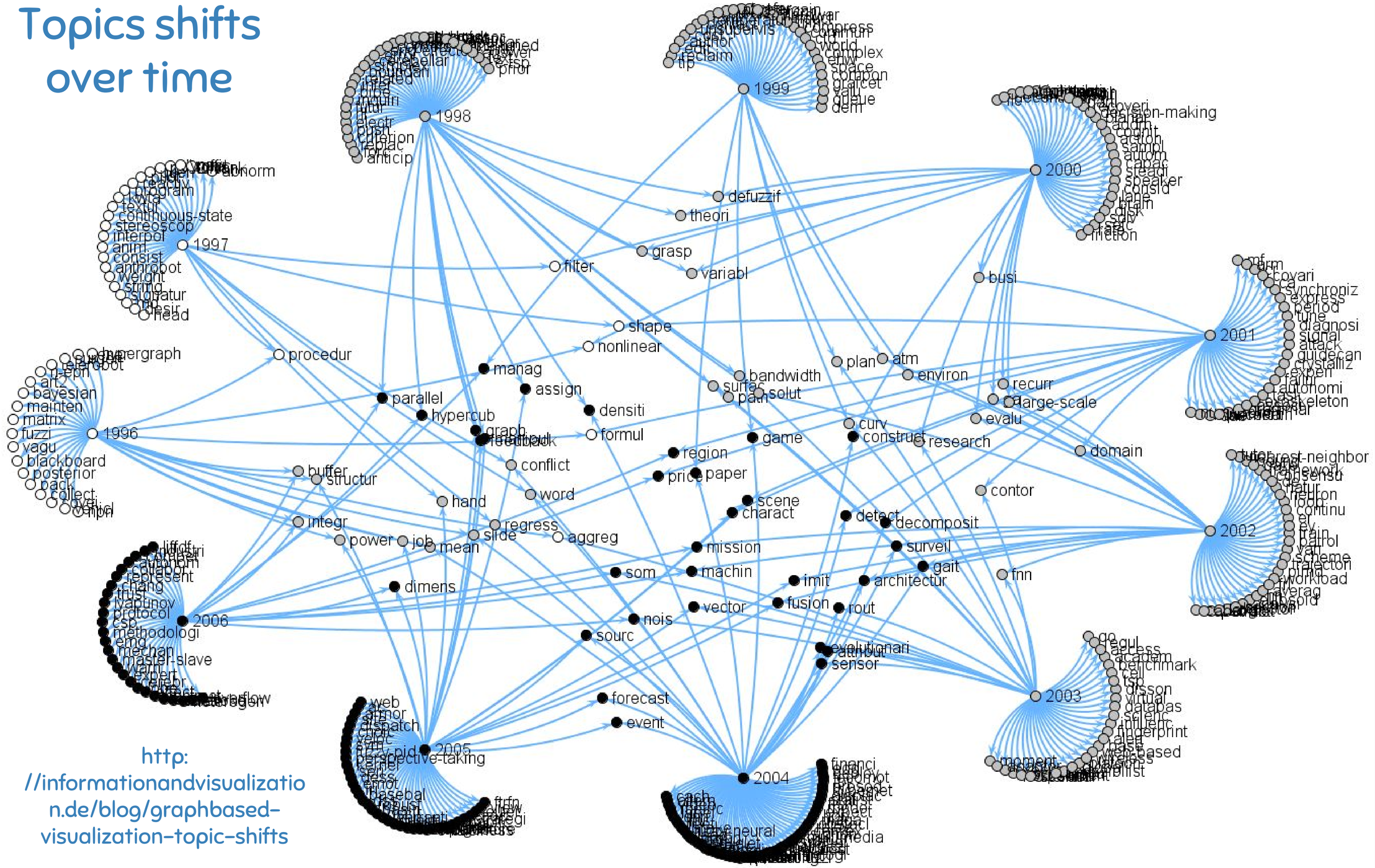


Social FlowThe most followed accounts among Twitter users who gave the debate to Vice President Biden.

Rayan vs Biden Debate (Twitter Reaction)

http://thecaucus.blogs.nytimes.com/2012/10/16/who-won-presidential-debate-on-twitter/?_r=1

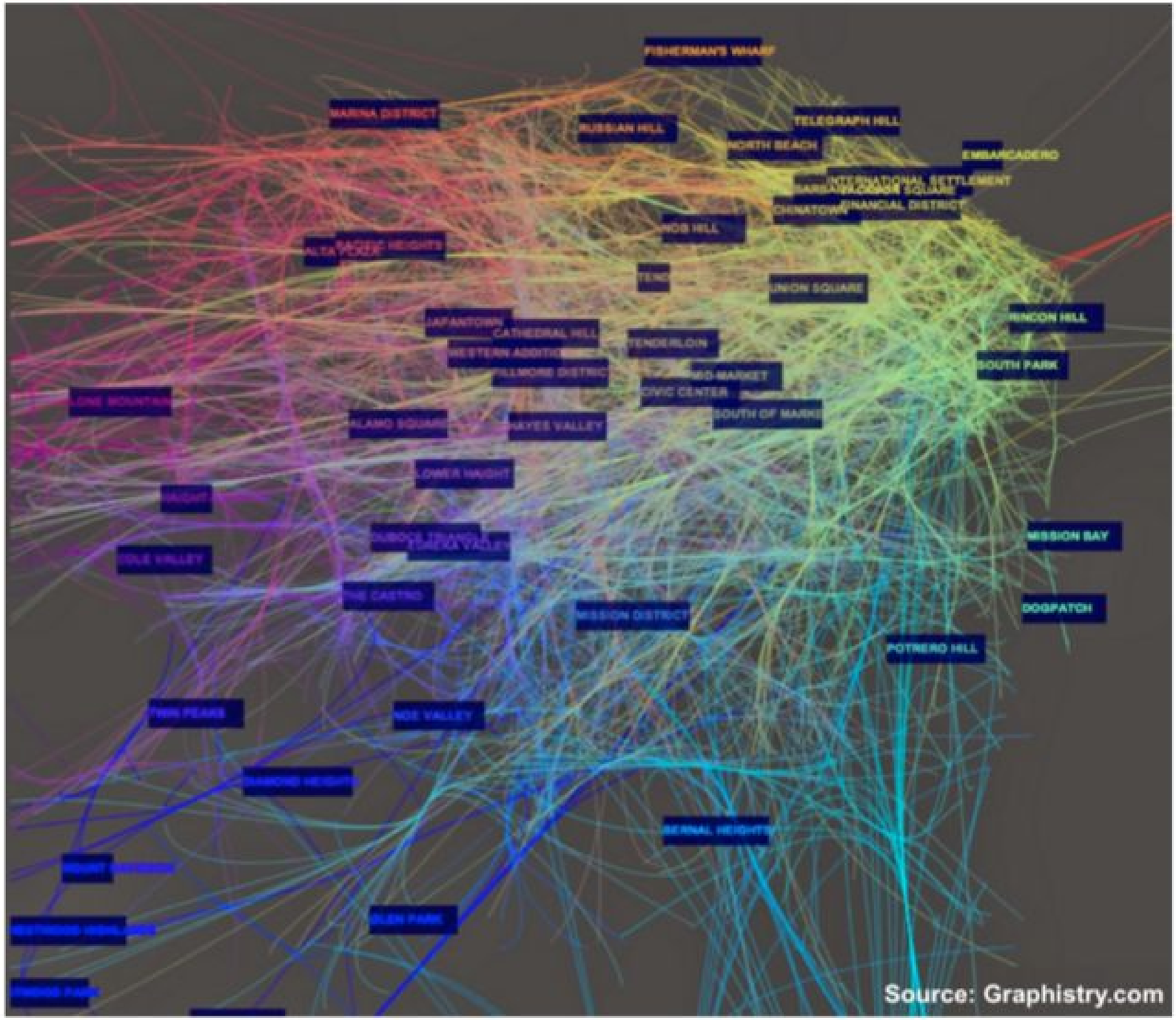
Topics shifts over time



http://informationandvisualization.de/blog/graphbased-visualization-topic-shifts

Uber Trips in San Francisco

http://radar.oreilly.com/2014/07/there-are-many-use-cases-for-graph-databases-and-analytics.html

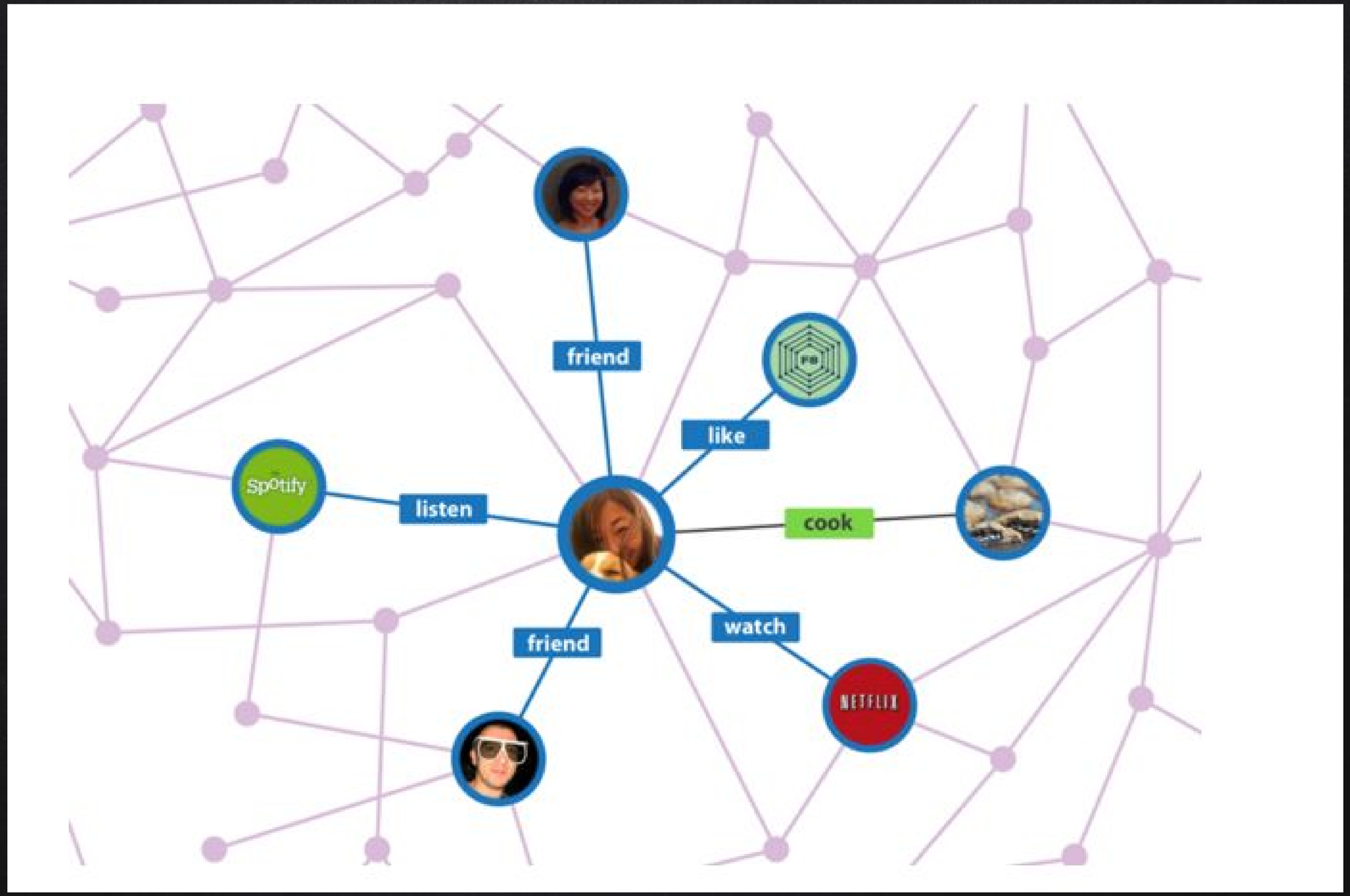


Interactive analyzer of Uber trips across San Francisco's micro-communities

Why graphs?

Why graphs?

- Abstractions of real-world data
- Capture relationships among entities
- Enable large-scale computations
- PageRank, SocialGraph, etc.
- Everyone is doing it!!!



Reading: http://www.businessinsider.com/explainer-what-exactly-is-the-social-graph-2012-3

Why graphs are useful for analytics?

Easily understood, interpretable information

Obtain Insight

Improve performance for some learning algorithms

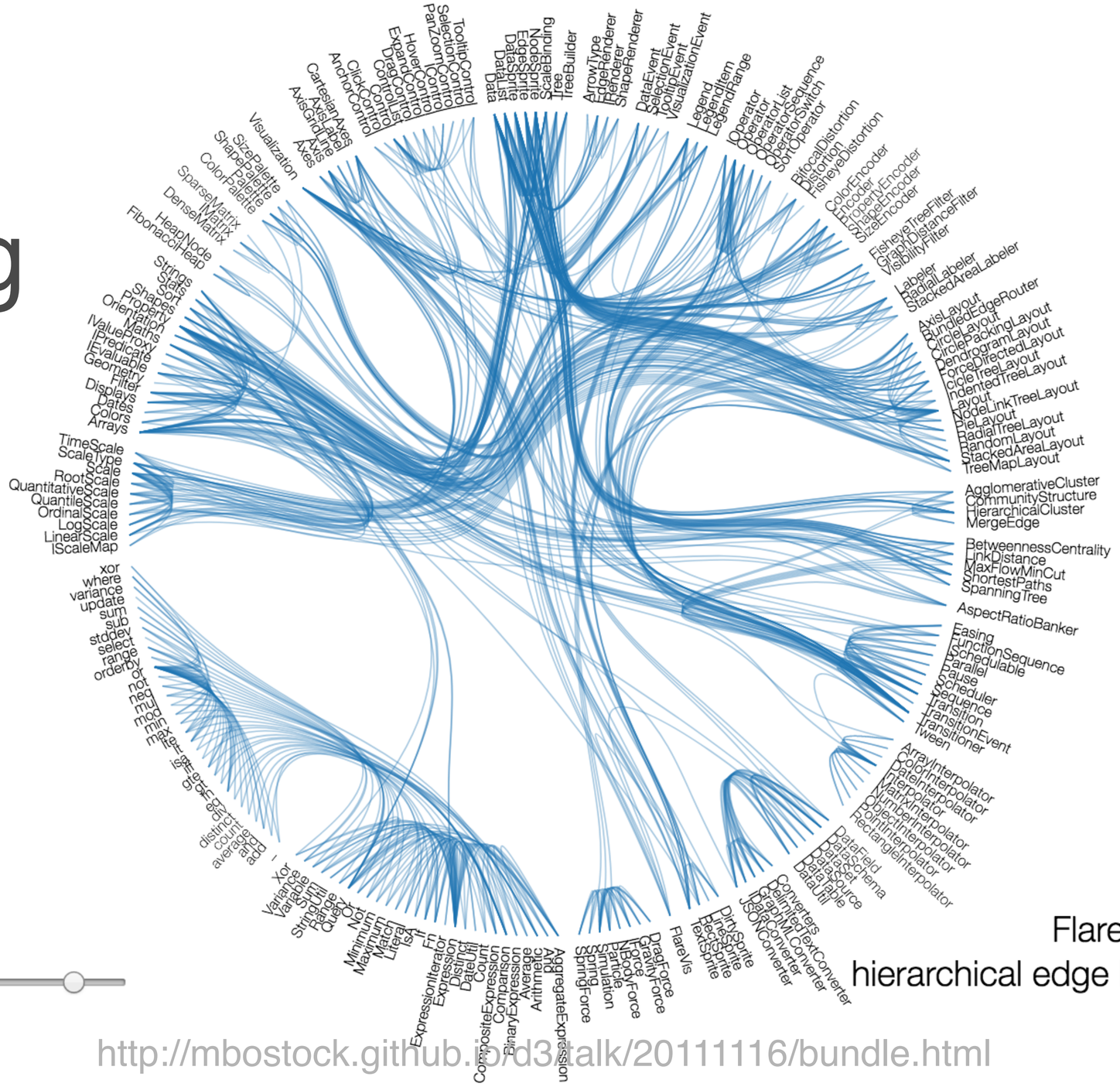
More materials

- Complex Labs
  - http://complexitylabs.io/product/network-theory-book/
  - Network theory overview
    - https://www.youtube.com/watch?v=qFcuovfgPTc
  - Graph theory overview
    - https://www.youtube.com/watch?v=82zlRaRUsaY

Graph Visualization

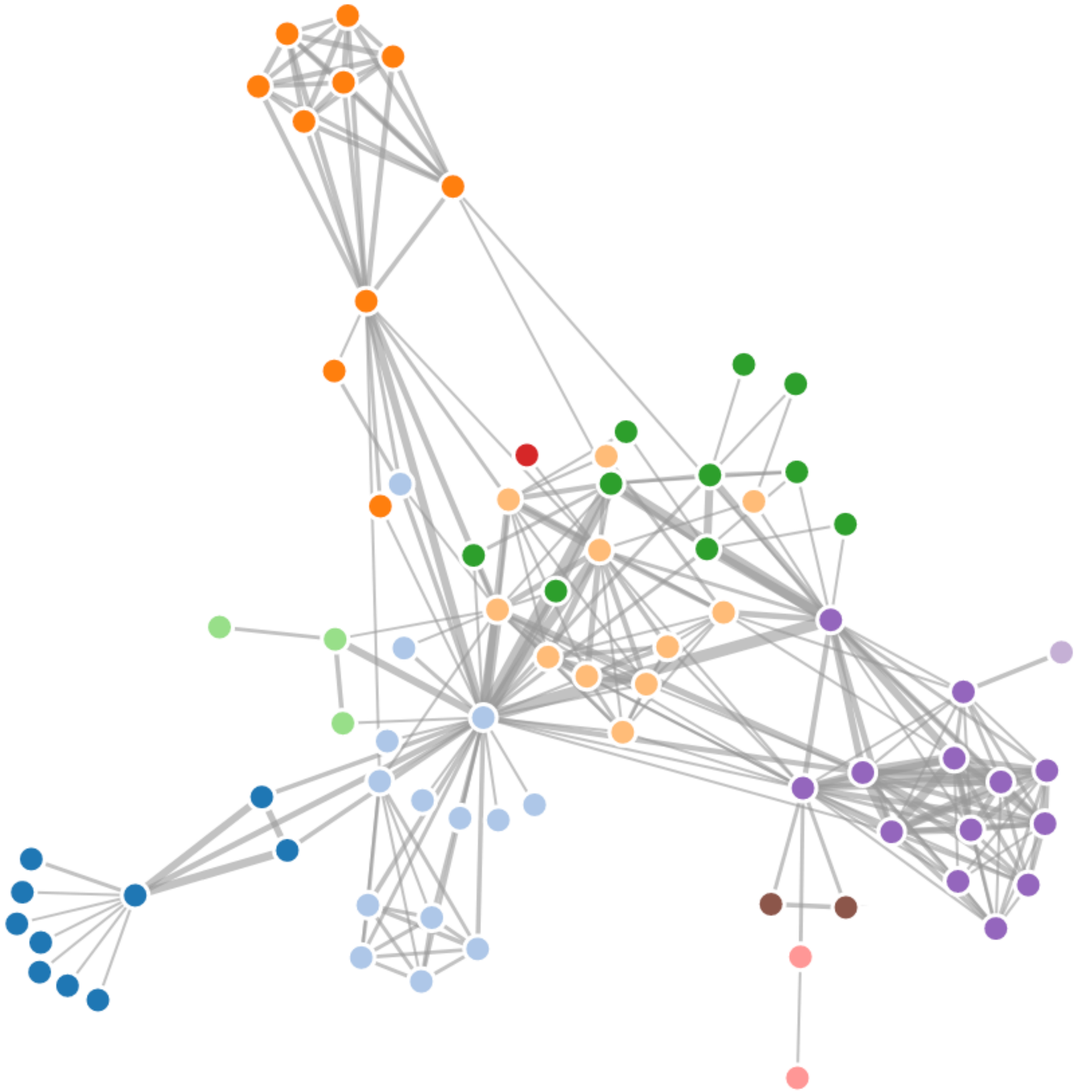
Teaser…..

Edge bundling



http://mbostock.github.io/d3/talk/20111116/bundle.html

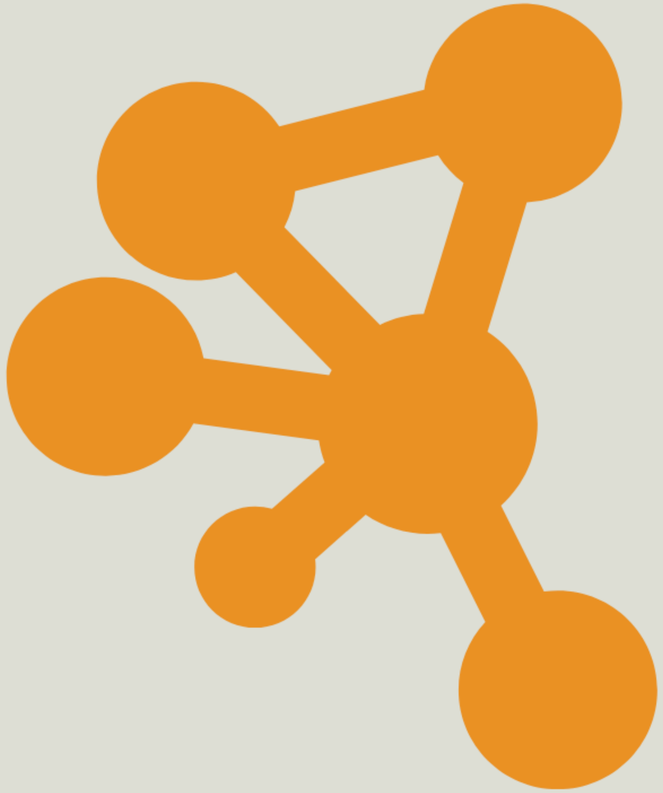
Force-directed Layout



https://bl.ocks.org/mbostock/4062045

Take home task

- http://cytoscape.org/



What is Cytoscape?

Cytoscape is an open source software platform for ***visualizing*** molecular interaction networks and biological pathways and ***integrating*** these networks with annotations, gene expression profiles and other state data. Although Cytoscape was originally designed for biological research, now it is a general platform for complex network analysis and visualization. Cytoscape *core* distribution provides a basic set of features for data integration, analysis, and visualization. Additional features are available as ***Apps*** (formerly called *Plugins*). Apps are available for network and molecular profiling analyses, new layouts, additional file format support, scripting, and connection with databases. They may be developed by anyone using the Cytoscape open API based on Java™ technology and App community development is encouraged. Most of the Apps are freely available from Cytoscape App Store.

Thanks!

Any questions?

You can find me at: beiwang@sci.utah.edu

CREDITS

Special thanks to all people who made and share these awesome resources for free:

- Presentation template designed by Slidesmash
- Photographs by unsplash.com and pexels.com
- Vector Icons by Matthew Skiles

Presentation Design

This presentation uses the following typographies and colors:

Free Fonts used:

http://www.1001fonts.com/oswald-font.html

https://www.fontsquirrel.com/fonts/open-sans

Colors used