http://poloclub.gatech.edu/cse6242

CSE6242 / CX4242:

# Data & Visual Analytics

Duen Horng (Polo) Chau
Assistant Professor
Associate Director, MS Analytics
Georgia Tech

# Google “Polo Chau” (only one in the world)

Georgia Tech | College of Computing

Bio CV Students Papers Teaching Funding Design

## POLO CHAU

Legal name:
Duen Horng Chau

Associate Director, MS in Analytics
Assistant Professor, School of Computational Science & Engineering

College of Computing
Georgia Tech

Admin: Carolyn Young  Financial Manager: Arlene Washington
polo@gatech.edu  www.cc.gatech.edu/~dchau
Office: Klaus 1324  404-385-7682
Google Scholar  YouTube videos

LinkedIn profile  Follow @PoloChau

### POSITIONS

May 2014 - Associate Director
MS in Analytics, Georgia Tech

Aug 2012 - Assistant Professor
School of Computational Science & Engineering, Georgia Tech

Dec 2012 - Dec 2015 Adjunct Assistant Professor
School of Interactive Computing, Georgia Tech

### EDUCATION

### Research Group & GitHub

Polo Club of DATA SCIENCE

**Students** (see more)
Robert Pienta, CSE PhD
Minsuk (Brian) Kahng, CS PhD
Shang-Tse Chen, CS PhD
Fred Hohman, CSE PhD
Nilaksh Das, CSE PhD
Peter Polack, MS CS
PhD student, UCLA
Madhuri Shanbhogue, MS CS
Dezhi (Andy) Fang, CS UG
Samuel Clarke, CS UG
Now: MS student, Carnegie Mellon
Nathan Dass, CS UG
Paras Jain, CS UG
PhD student, UC Berkeley
Matthew Keezer, CS UG
MS CS student, Georgia Tech
Jake Williams, CS UG

**Alumni** (see more)
Acar Tamersoy, CS PhD
Research Scientist, Symantec
Chad Stolper, CS PhD
Assist. Prof, Southwestern Univ.
Zhiyuan (Jerry) Lin, CS UG

# How to address Polo?

**Grammatically correct**

Prof. Chau

Dr. Chau

**Grammatically incorrect, but popular**

Prof. Polo

Dr. Polo

# Course Registration

This class room seats 305. **Currently all physical seats are taken.** If you are on the waitlist, please wait for seats to released (some students will typically “drop” after today).

- As of 2:30pm today (Aug 22, 2017)
  - **CSE 6242 A**
    - 251/253 seats filled
    - 33/200 waitlist slots taken
  - **CX 4242 A**
    - 52/52 seats filled
    - 3/100 waitlist slots taken
  - (Distance-learning CSE 6242 Q: 5 students)

# Course TAs **Be very very nice to them!**

**Kiran** Sudhir (Head TA)

**Varun** Bezzam

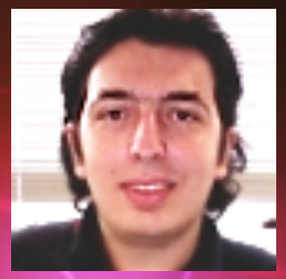
**Yuyu** Zhang

**Akanksha** Bindal

**Vishal** Bhatnagar

**Vivek** Iyer

Office hours and locations (TBD) on course homepage
**poloclub.gatech.edu/cse6242**



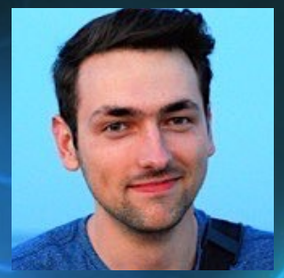
Acar
@Symantec

Robert

Brian

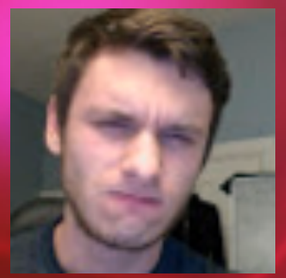
Chad
@Southwestern Univ

Shang



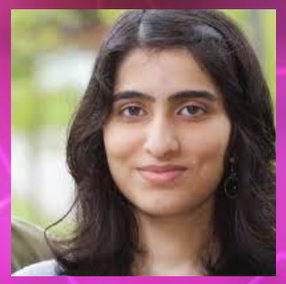
Fred

Nilaksh



Peter
➡ UCLA PhD

Shan
@Oracle



Meera
@Microsoft

Polo Club of DATA SCIENCE

Jerry
Stanford PhD

Samuel

Srishti
@Apple

Florian
@Facebook

Aakash
@Google

Paras
➡ Berkeley PhD

Victor
@Facebook

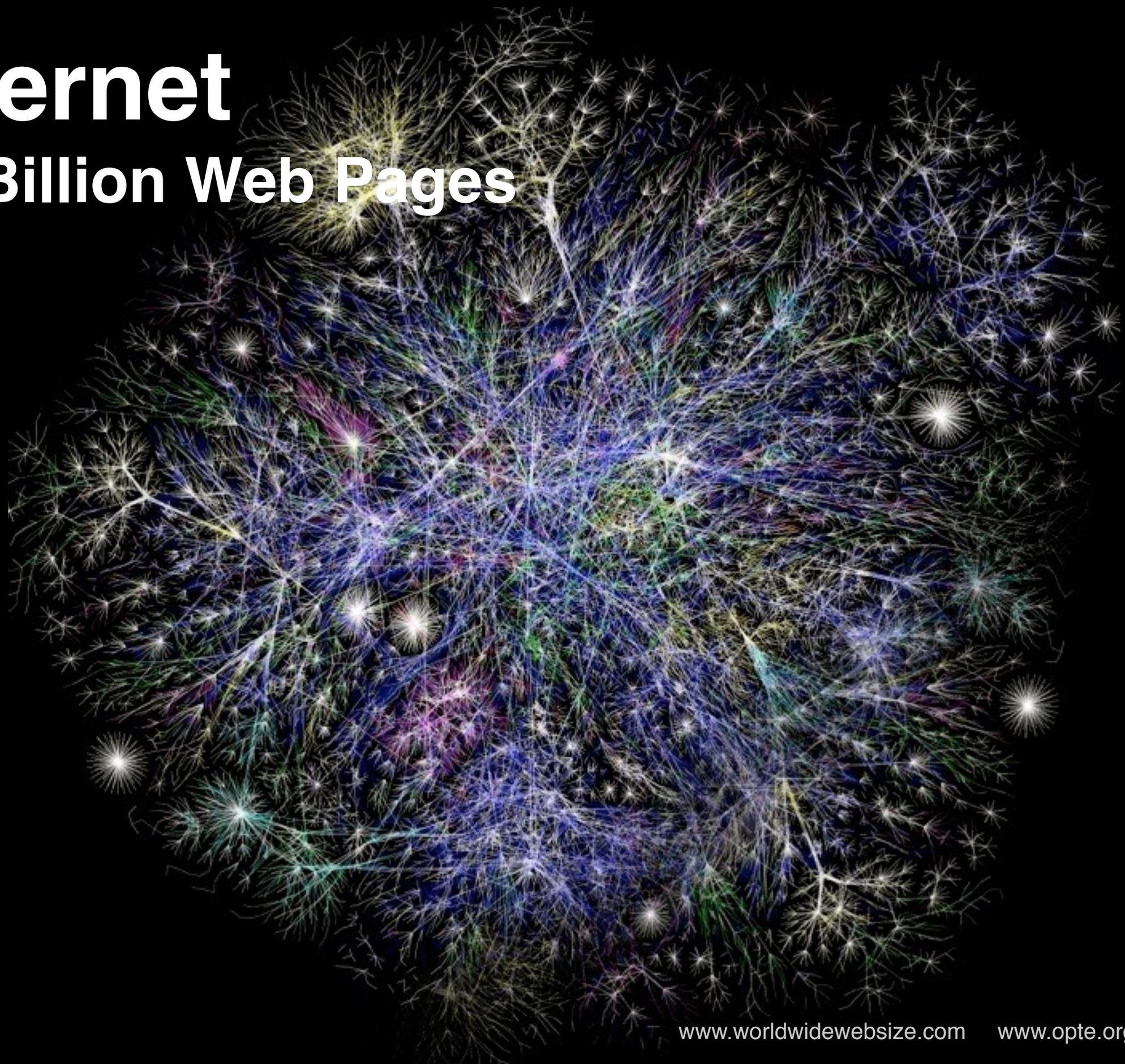
Andy

Polo Club of DATA SCIENCE

# We work with (really) large data.

# Internet

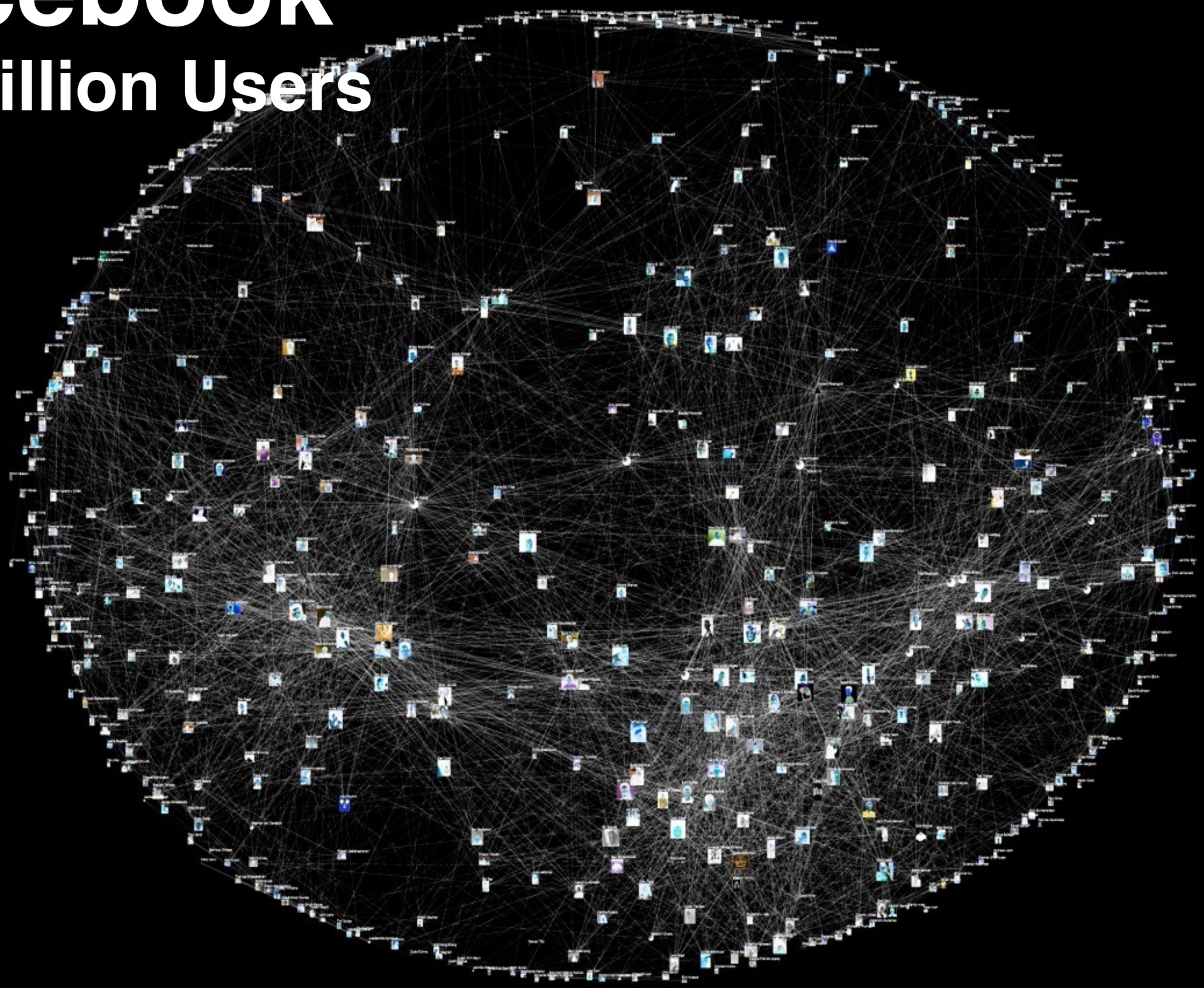
## 50 Billion Web Pages



www.worldwidewebsize.com www.opte.org

# Facebook

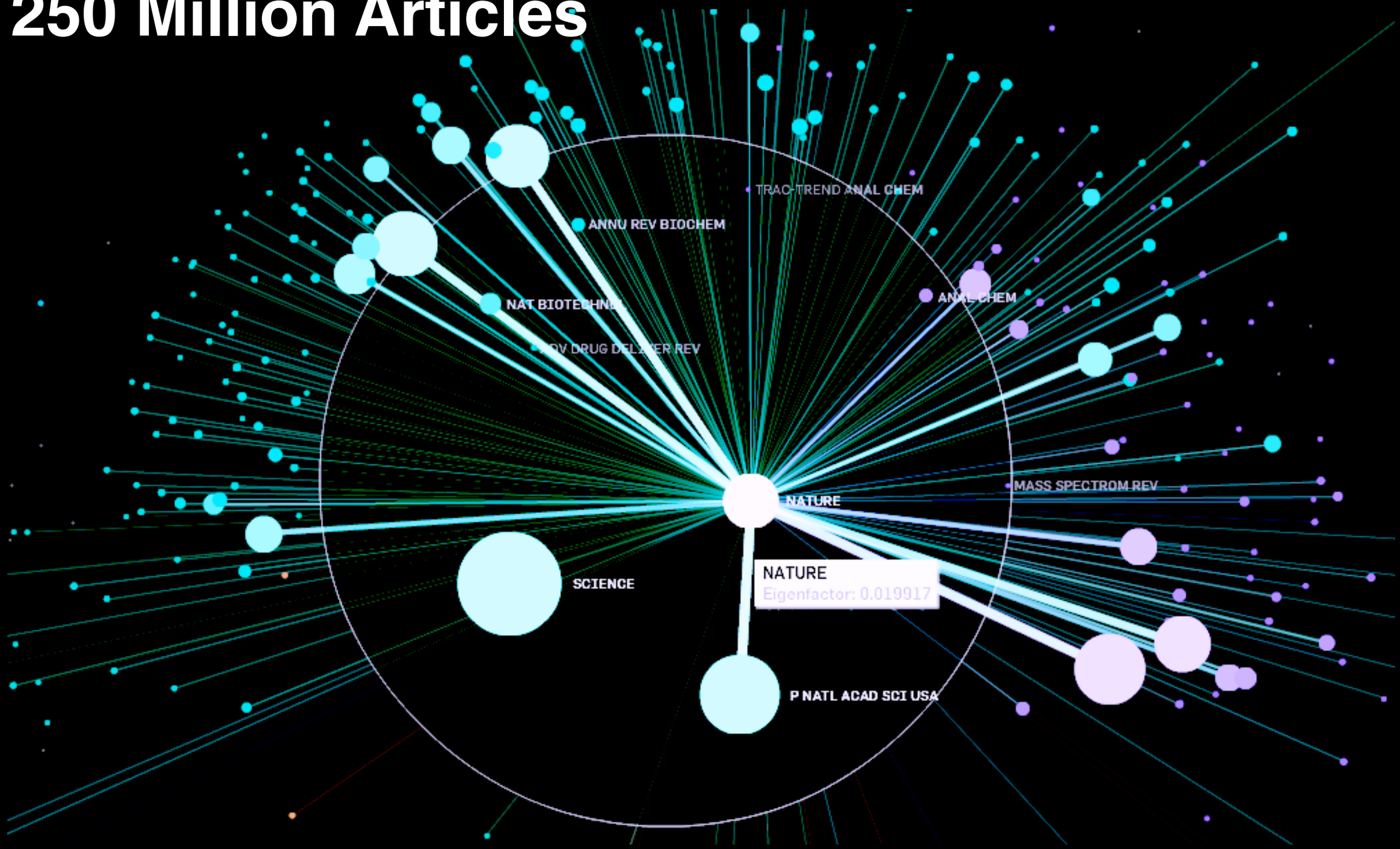
## 1.2 Billion Users



Modified from Marc_Smith, flickr

# Citation Network

## 250 Million Articles




www.scirus.com/press/html/feb_2006.html#2 Modified from well-formed.eigenfactor.org

# Many More

twitter

Who-follows-whom (500 million users)

amazon

Who-buys-what (120 million users)

at&t **cellphone network**

Who-calls-whom (100 million users)

## Protein-protein interactions

200 million possible interactions in human genome

Sources: www.selectscience.net www.phonedog.com www.mediabistro.com www.practicalecommerce.com/

# “Big Data” Analyzed

| Graph | Nodes | Edges |
|---|---|---|
| YahooWeb | 1.4 Billion | 6 Billion |
| Symantec Machine-File Graph | 1 Billion | **37 Billion** |
| Twitter | 104 Million | 3.7 Billion |
| Phone call network | 30 Million | 260 Million |

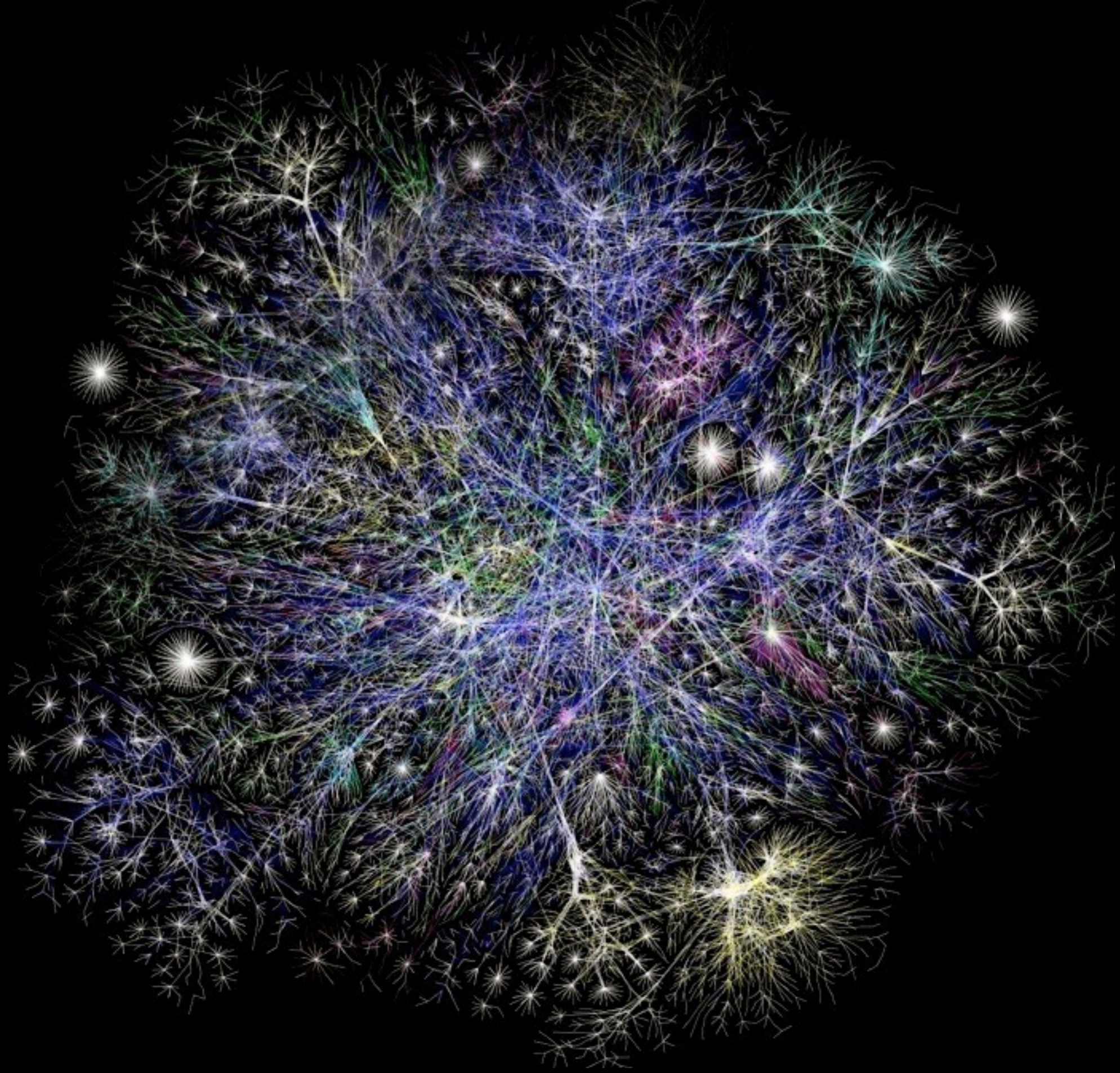
**We also work with small data.**
**Small data also needs love.**

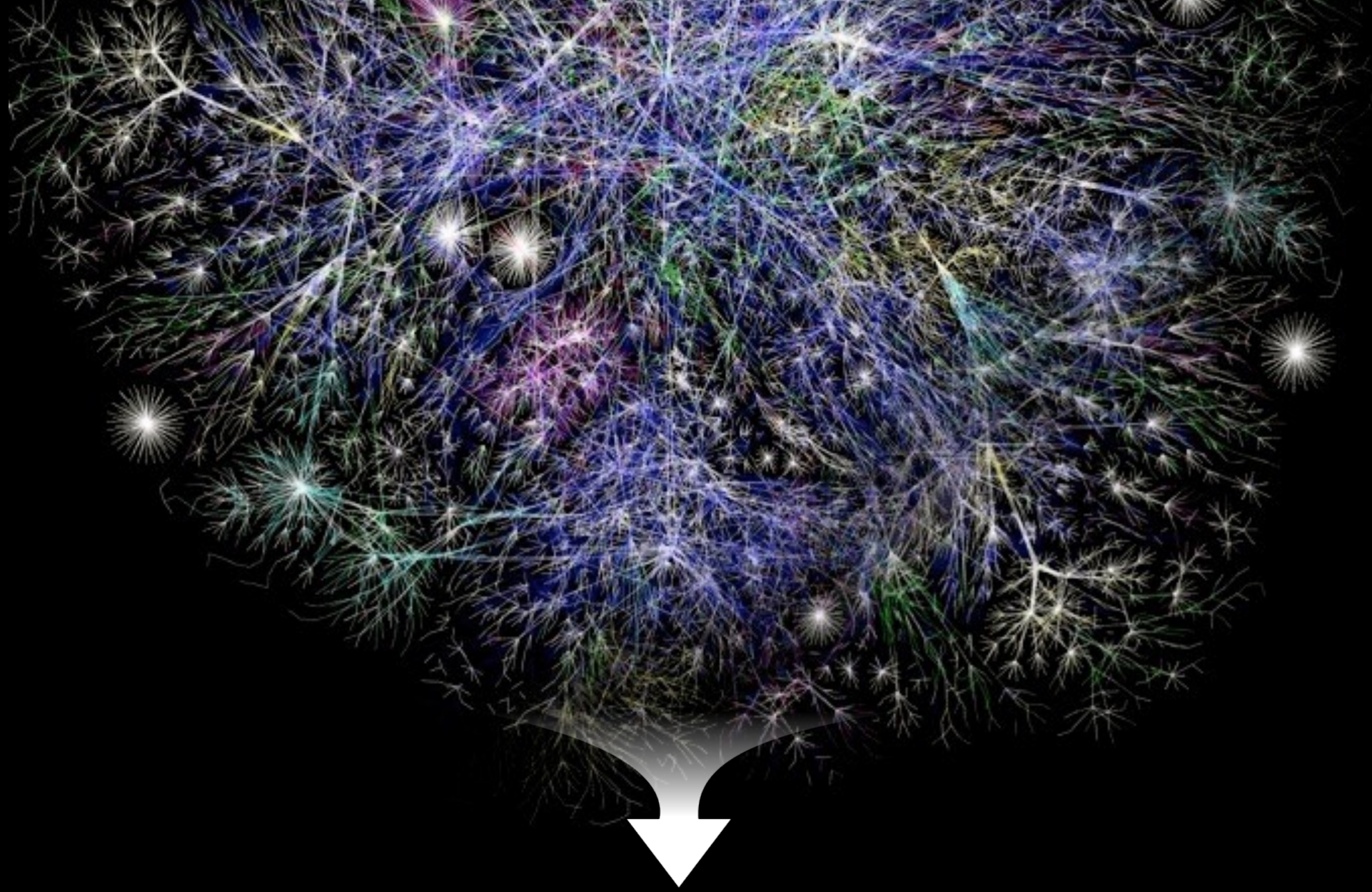
7

# 7±2

Number of items an average human holds in working memory

*George Miller, 1956*





7

# Data

# Insights

## How to do that?

# COMPUTATION
# +
# HUMAN INTUITION

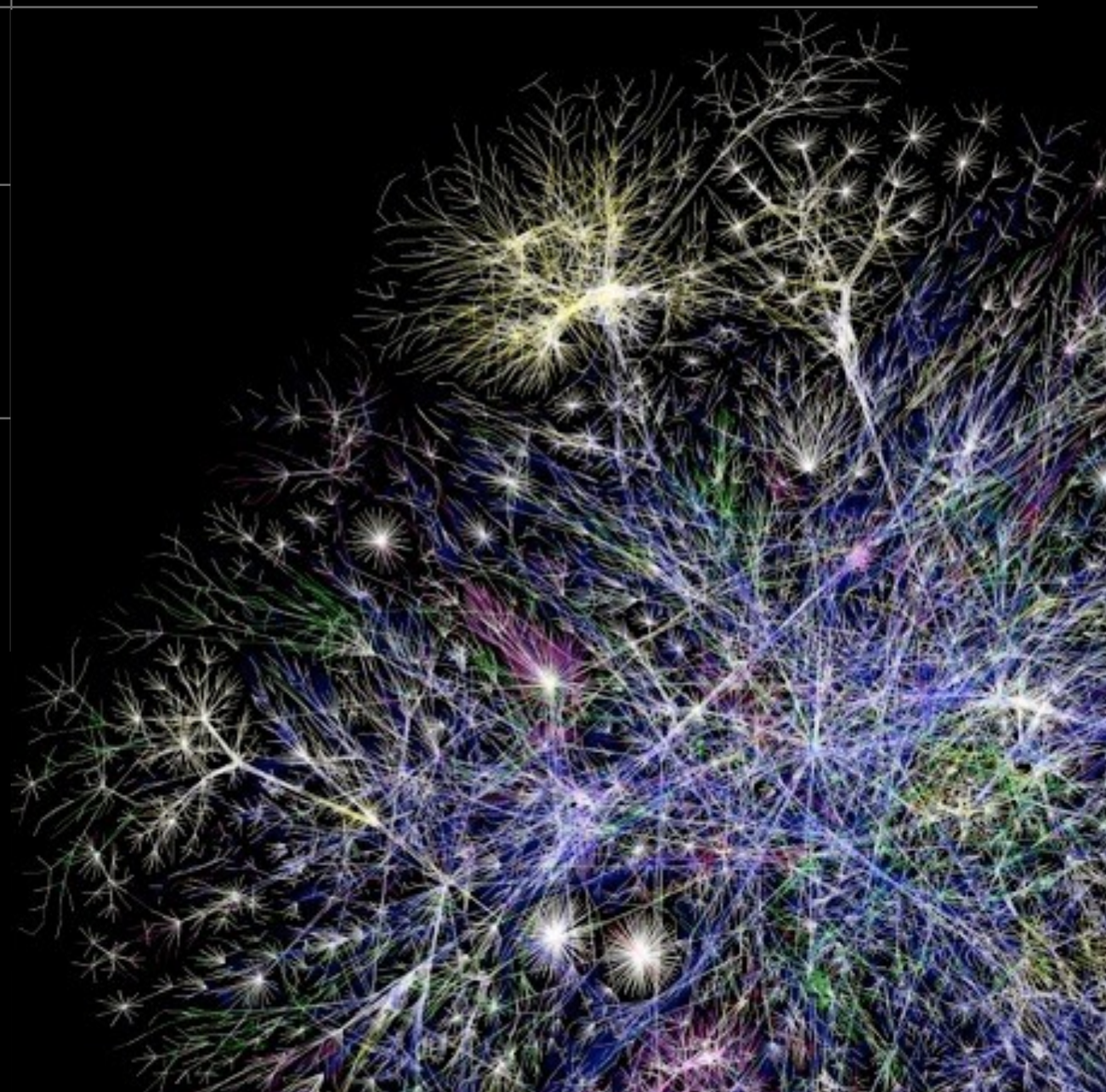
# How to do that?

| COMPUTATION | INTERACTIVE VIS |
| --- | --- |
| Automatic | User-driven; iterative |
| Summarization, clustering, classification | Interaction, visualization |
| >Millions of nodes | Thousands of nodes |

Both develop methods for making sense of network data

# How to do that?

| COMPUTATION | INTERACTIVE VIS |
| --- | --- |
| Automatic | |
| Summarization, clustering, classification | |
| >Millions of nodes | |



# How to do that?

| COMPUTATION | INTERACTIVE VIS |
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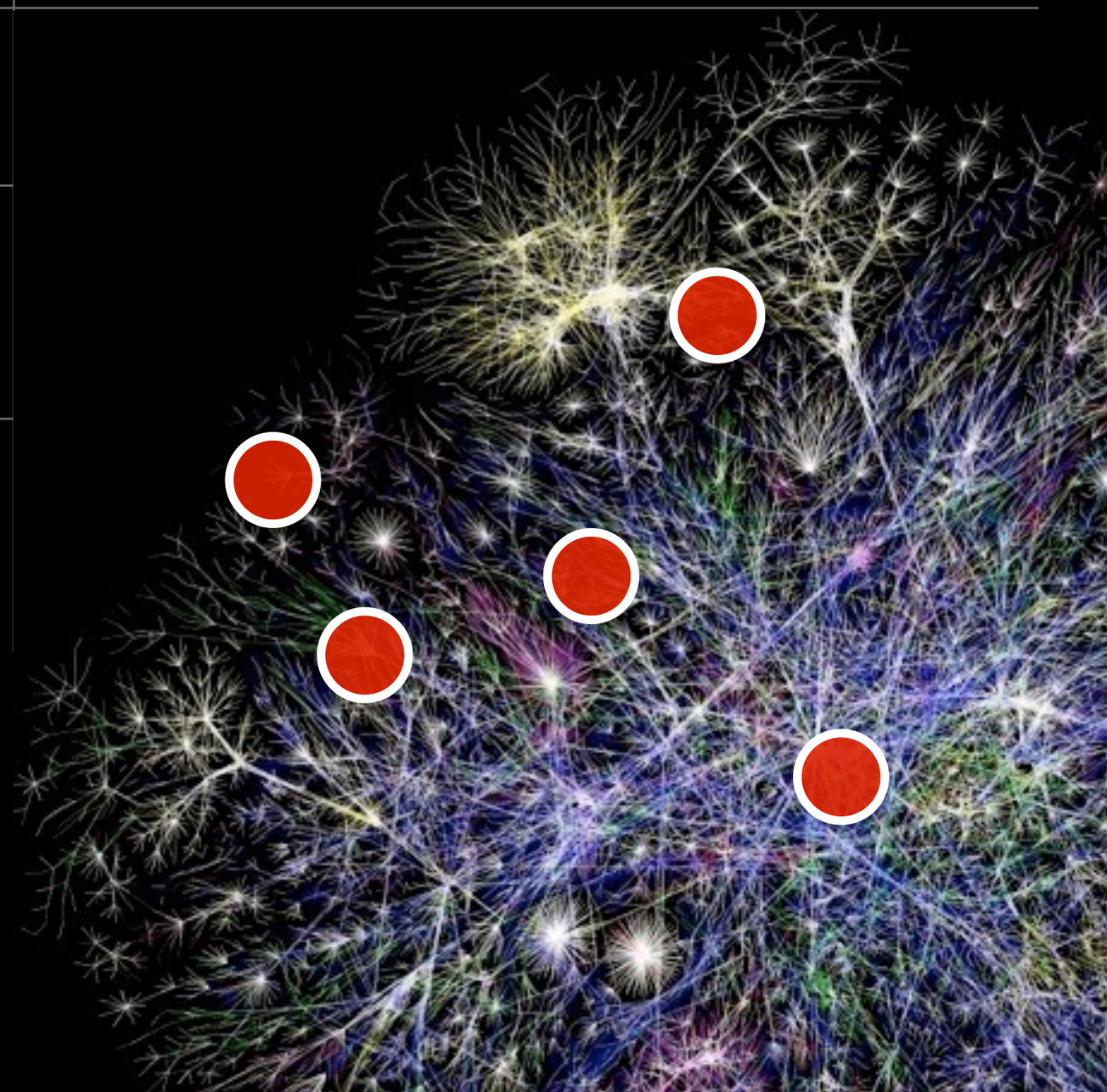
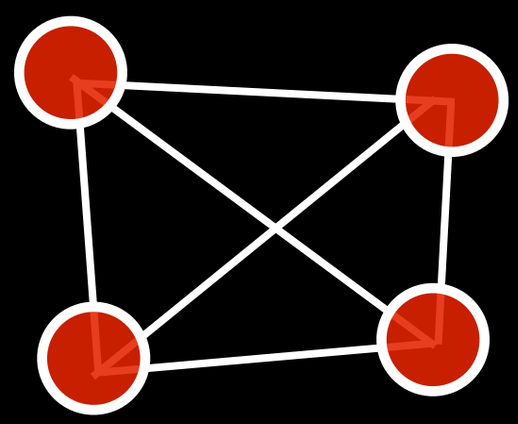


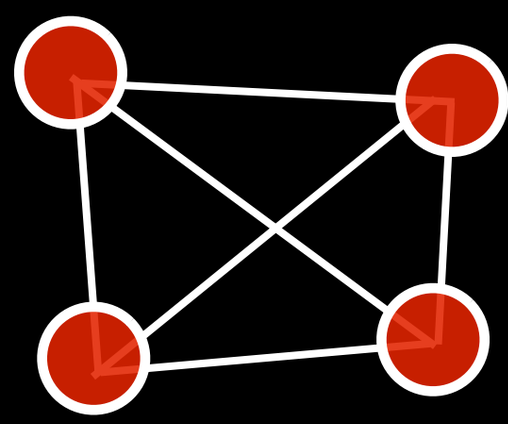
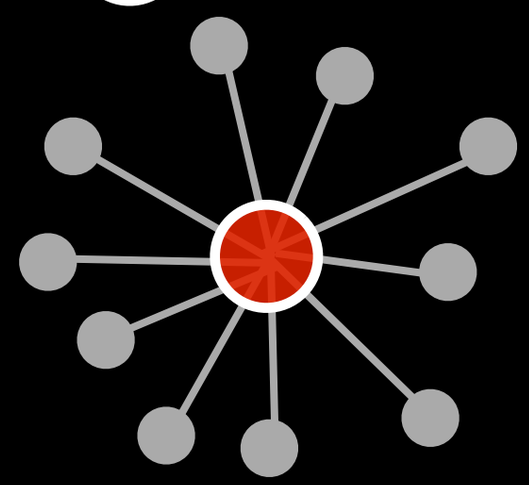
# How to do that?

| COMPUTATION | INTERACTIVE VIS |
| --- | --- |
| ⋮ | User-driven; iterative |
| | Interaction, visualization |
| | Thousands of nodes |

# How to do that?

| COMPUTATION | INTERACTIVE VIS |
| --- | --- |
|  | User-driven; iterative |
| | Interaction, visualization |
|  | Thousands of nodes |

# How to do that?

| COMPUTATION | INTERACTIVE VIS |
| --- | --- |
|  | User-driven; iterative |
|  | Interaction, visualization |
| | Thousands of nodes |

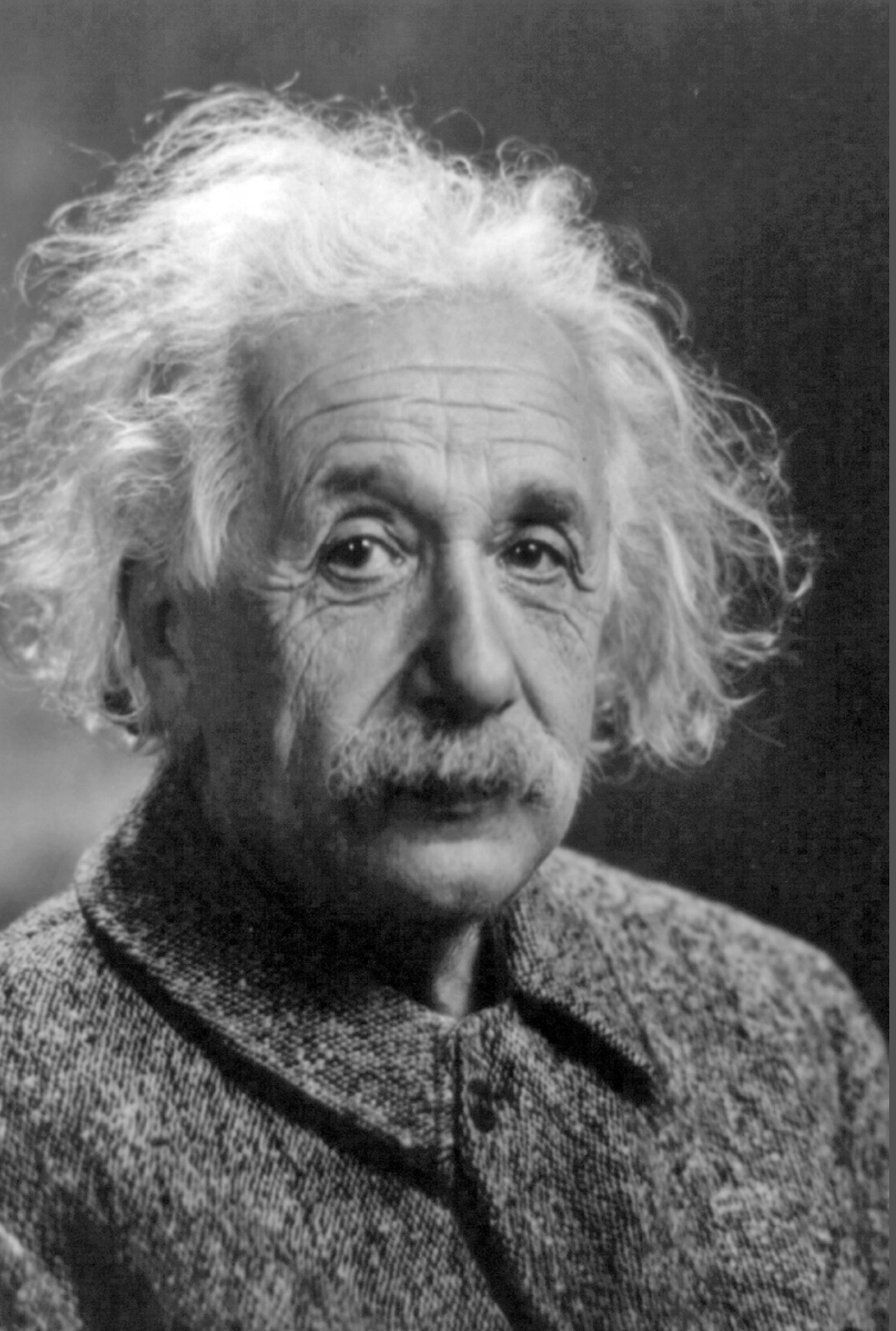
# Our Approach for Big Data Analytics

| DATA MINING | HCI Human-Computer Interaction |
| --- | --- |
| Automatic | User-driven; iterative |
| Summarization, clustering, classification | Interaction, visualization |
| >Millions of items | Thousands of items |

Our research combines the
**Best of Both Worlds**

## Our mission & vision:

**Scalable, interactive, usable tools for big data analytics**



“Computers are incredibly fast accurate, and stupid.

Human beings are incredibly slow, inaccurate, and brilliant.

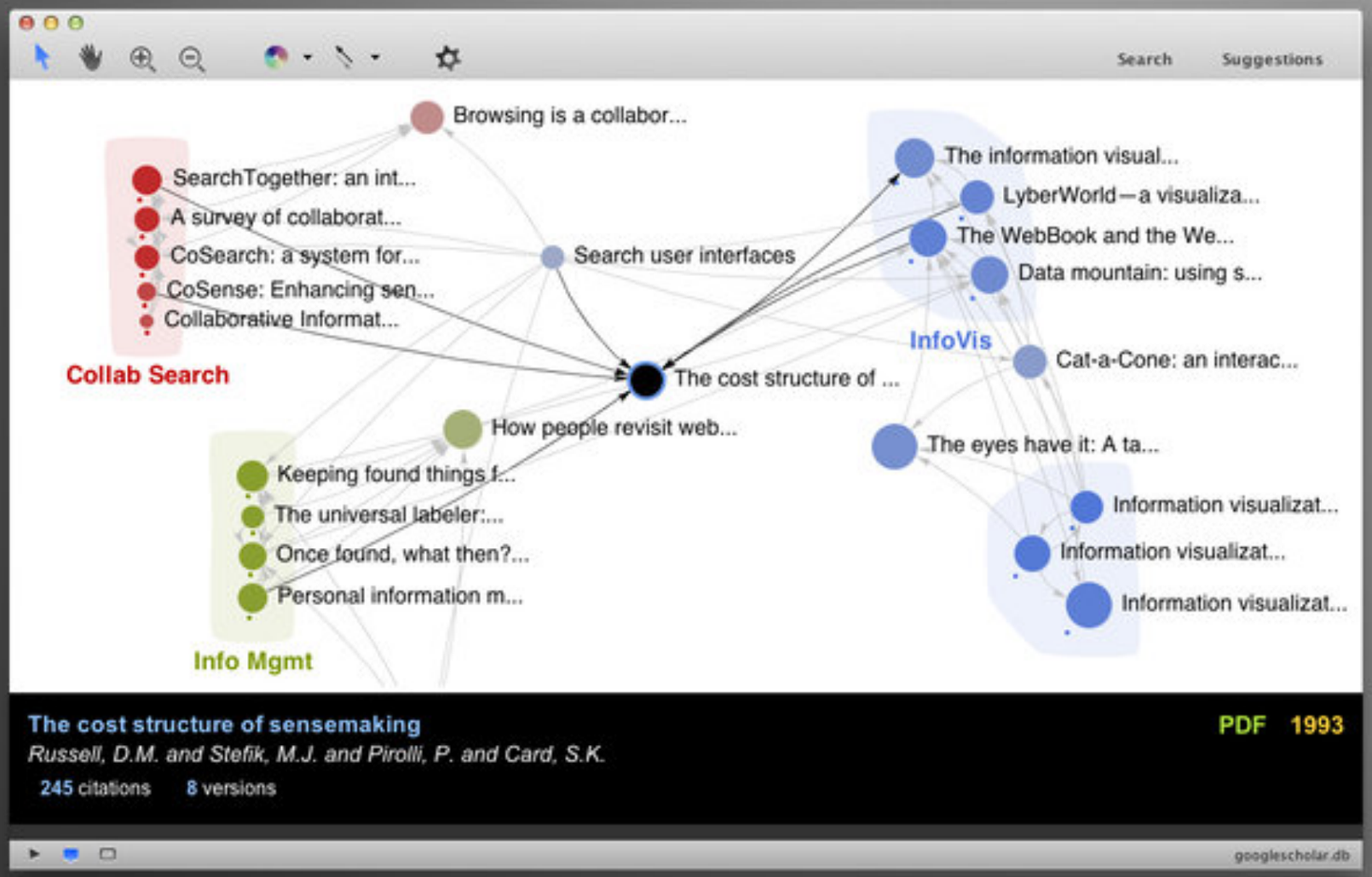
Together they are powerful beyond imagination.”

(Einstein might or might not have said this.)

# Machine Learning + Visualization

## Recently received $1.2 Million NSF award

http://www.scs.gatech.edu/news/522401/12m-nsf-award-helps-consumers-enter-age-big-data

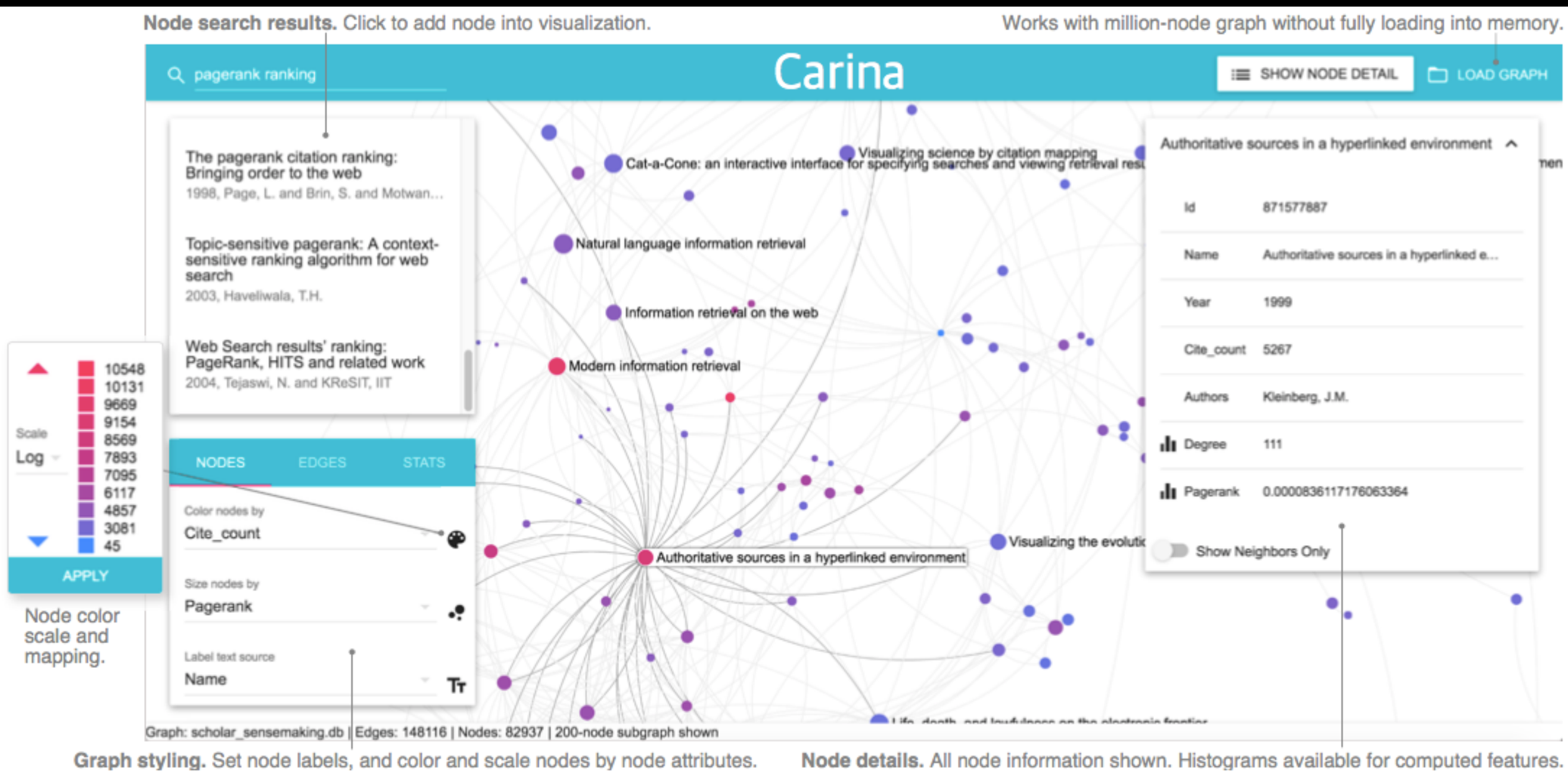



# Apolo

Explore million-node graphs in real time

Apolo: Making Sense of Large Network Data by Combining Rich User Interaction and Machine Learning. CHI 2011.

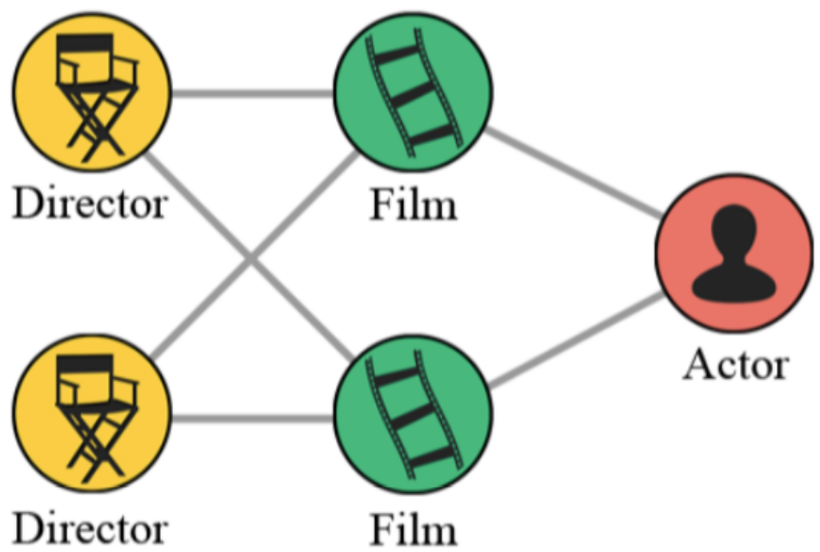
# **Carina:** Million-node Graph Exploration in Web Browser [www'17]

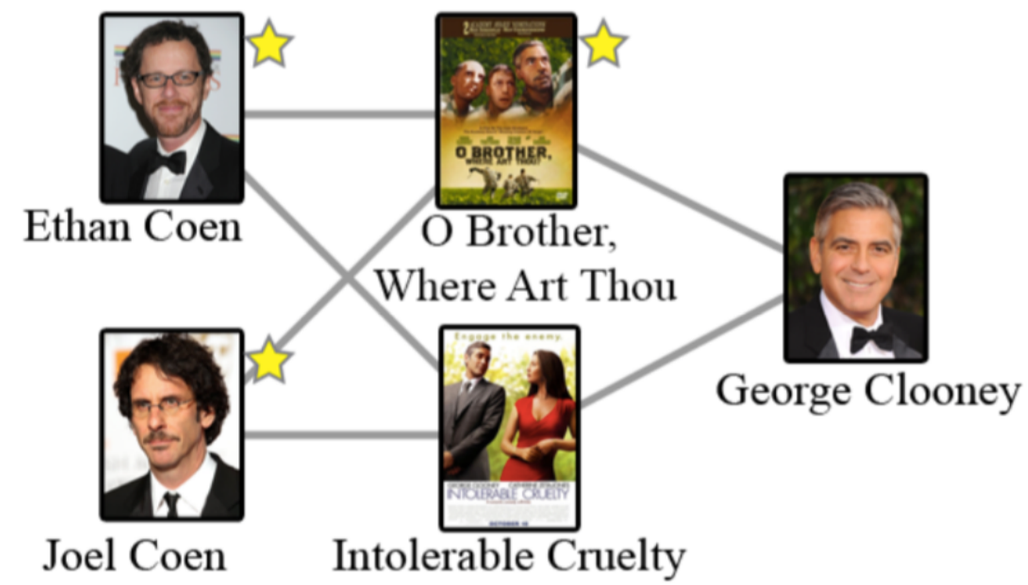



**Carina: Interactive Million-Node Graph Visualization using Web Browser Technologies.**
Dezhi (Andy) Fang, Mahew Keezer, Jacob Williams, Kshitij Kulkarni, Robert Pienta, Duen Horng (Polo) Chau.
WWW'17 Poster

# VISAGE: Interactive Visual Graph Querying

## **SIGMOD'17 Best Demo,** honorable mention




Find **co-directors** who made at least **two films** together, starring the same **actor**.

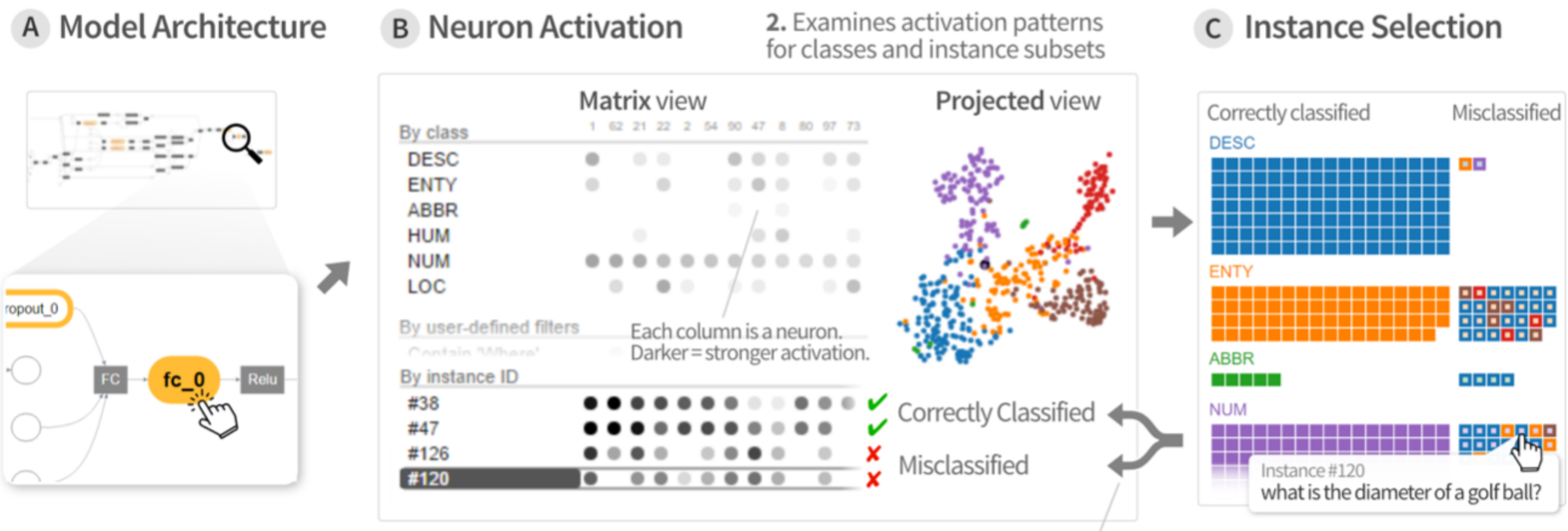
```
MATCH (d1:director)--(f1:film),
  (d1)--(f2:film), (d1)--(f3:film),
  (f1)--(d2:director)--(f2),
  (d2)--(f3),
  (f1)--(a:actor)--(f2), (a)--(f3)
WHERE f1.decade = 1990 AND d1 <> d2
RETURN d1, d2, f1, f2, f3, a
```

**VISAGE: Interactive Visual Graph Querying**.
Robert Pienta, Acar Tamersoy, Sham Navathe, Hanghang Tong, Alex Endert, Duen Horng Chau.
*International Working Conference on Advanced Visual Interfaces (AVI 2016).*

# ActiVis

Visualization & Interpretation of Deep Learning Models

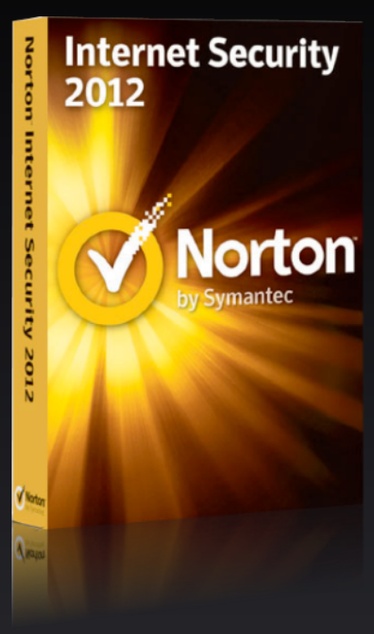
Deployed on ML platform of facebook

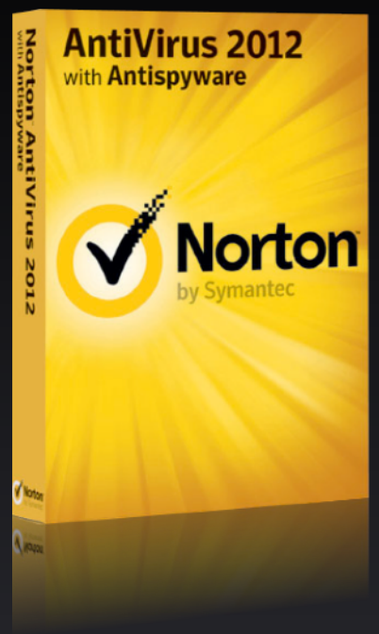


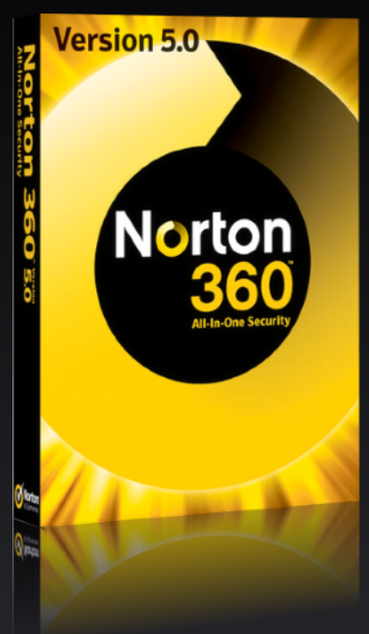

**ActiVis: Visual Exploration of Industry-Scale Deep Neural Network Models**.
Minsuk Kahng, Pierre Andrews, Aditya Kalro, Duen Horng (Polo) Chau.
*IEEE Transactions on Visualization and Computer Graphics (Proc. VAST'17), Jan 2018.*

Polo’s primary application area:

# Cyber Security




# Polonium & AESOP

**Patented** with Symantec

Finds malware from **37 billion** file relationships

Serving **120 million** users worldwide

Published at SDM’11, KDD’14

# NetProbe

## Auction Fraud Detection on eBay


THE WALL STREET JOURNAL.

MSNBC

CNNMoney.com
A Service of CNN, Fortune & Money

USA TODAY

KDKA 2


# MARCO

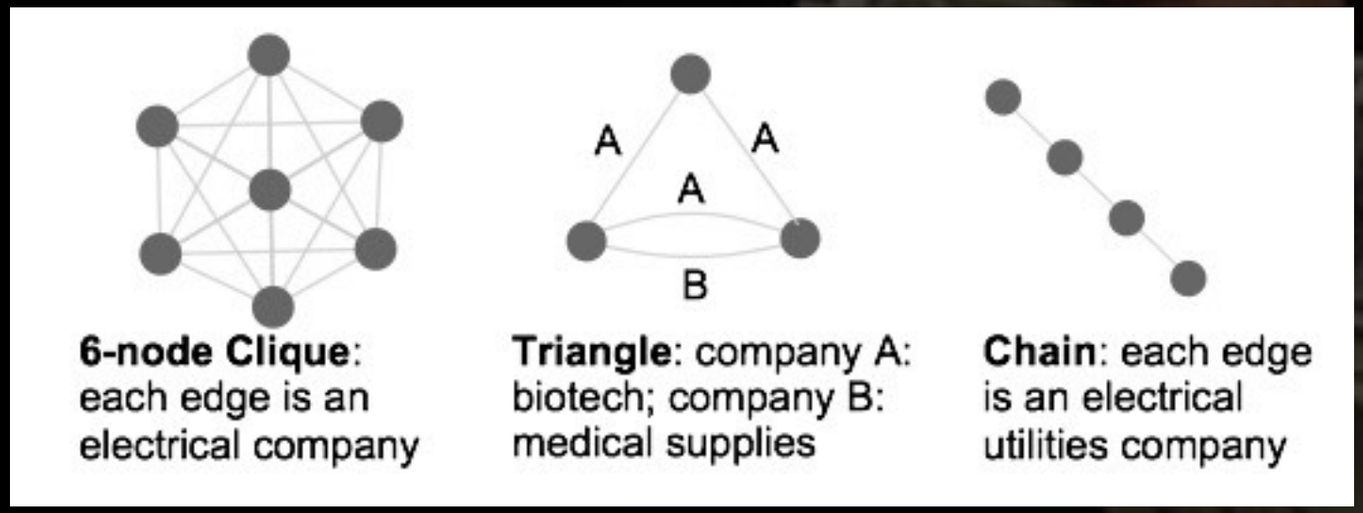
## Detecting Fake Yelp Reviews

**Best papers of SDM 2014**

(top data mining conference)

# Insider Trading Detection

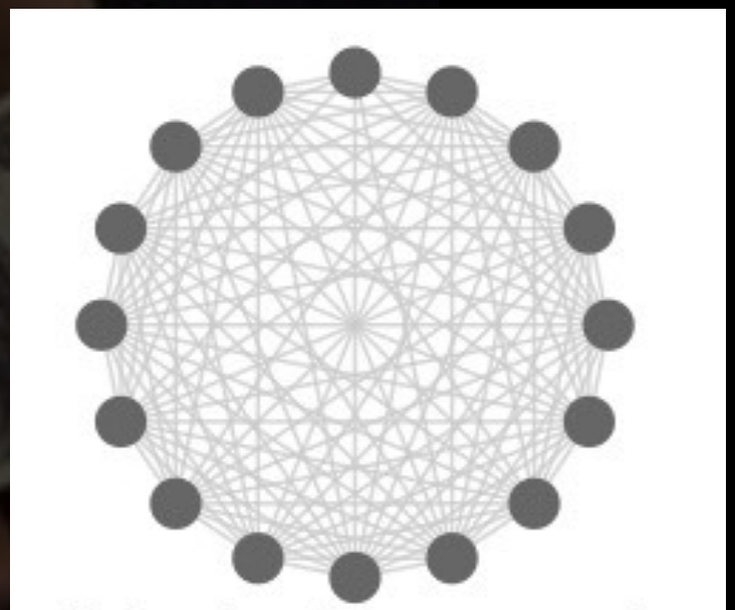
## with Securities and Exchange Commission (SEC)



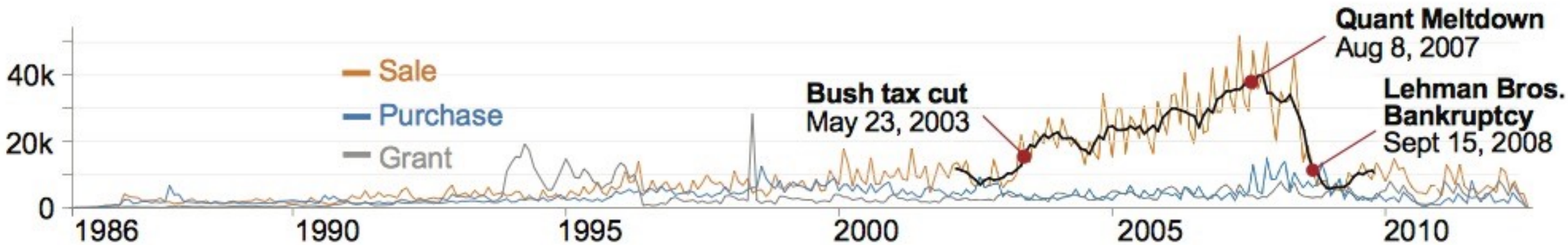

**6-node Clique**: each edge is an electrical company

**Triangle**: company A: biotech; company B: medical supplies

**Chain**: each edge is an electrical utilities company



Each edge above corresponds to an Electrical Utilities Company



# Logistics

**Course homepage**
All assignments,
slides posted here

poloclub.gatech.edu/cse6242/

**Discussion, Q&A,**
**find teammates**

Piazza: **goo.gl/t5k2bb**

or https://piazza.com/gatech/fall2017/cse6242aqcx4242a/

Make sure you're at the right Piazza!
(CSE 6242 O has its Piazza too)

**Assignment**
**Submission**

T-Square
(Use Piazza for discussion)

# Course Homepage

For syllabus, HWs, projects, datasets, etc.

Google “cse6242”
poloclub.gatech.edu/cse6242/2017fall

All students must first review prerequisites & course expectation.

CSE6242 / CX4242, Fall 2017

## Data and Visual Analytics

### Georgia Tech, College of Computing

# Join Piazza ASAP

goo.gl/t5k2bb

## Announcements and Discussion

In-class announcement slides

**We use Piazza for announcements and discussion.**

Everyone must join this class's Piazza, at https://piazza.com/gatech/fall2017/cse6242aqcx4242a/.

**Double check that you are joining the right Piazza!**

When you have questions about class, homework, project, etc., post your questions there. Our teaching staff and your fellow classmates will help answer them quickly. You can also use Piazza to find project teammates.

T-square will only be used for submission of assignments and projects.

While we welcome everyone to share their experiences in tackling issues and helping each other out, but please do not post your answers, as that may affect the learning experience of your fellow classmates.

# Important to join Piazza because…

**The fastest way** to get help with homework assignments is to post your questions on Piazza. If you prefer that your question addresses to only our TAs and the instructor, you can use the *private post* feature (i.e., check the "Individual Students(s) / Instructors(s)" radio box).

# Important to join Piazza because…

- Polo will announce events related to this class and data science in general
  - Distinguished lectures
  - Seminars
  - Hackathons (**free food**, prizes)
  - Company recruitment events (**free food**, swag)

# Course Goals

# What is Data & Visual Analytics?

# What is Data & Visual Analytics?

No formal definition!

# What is Data & Visual Analytics?

No formal definition!

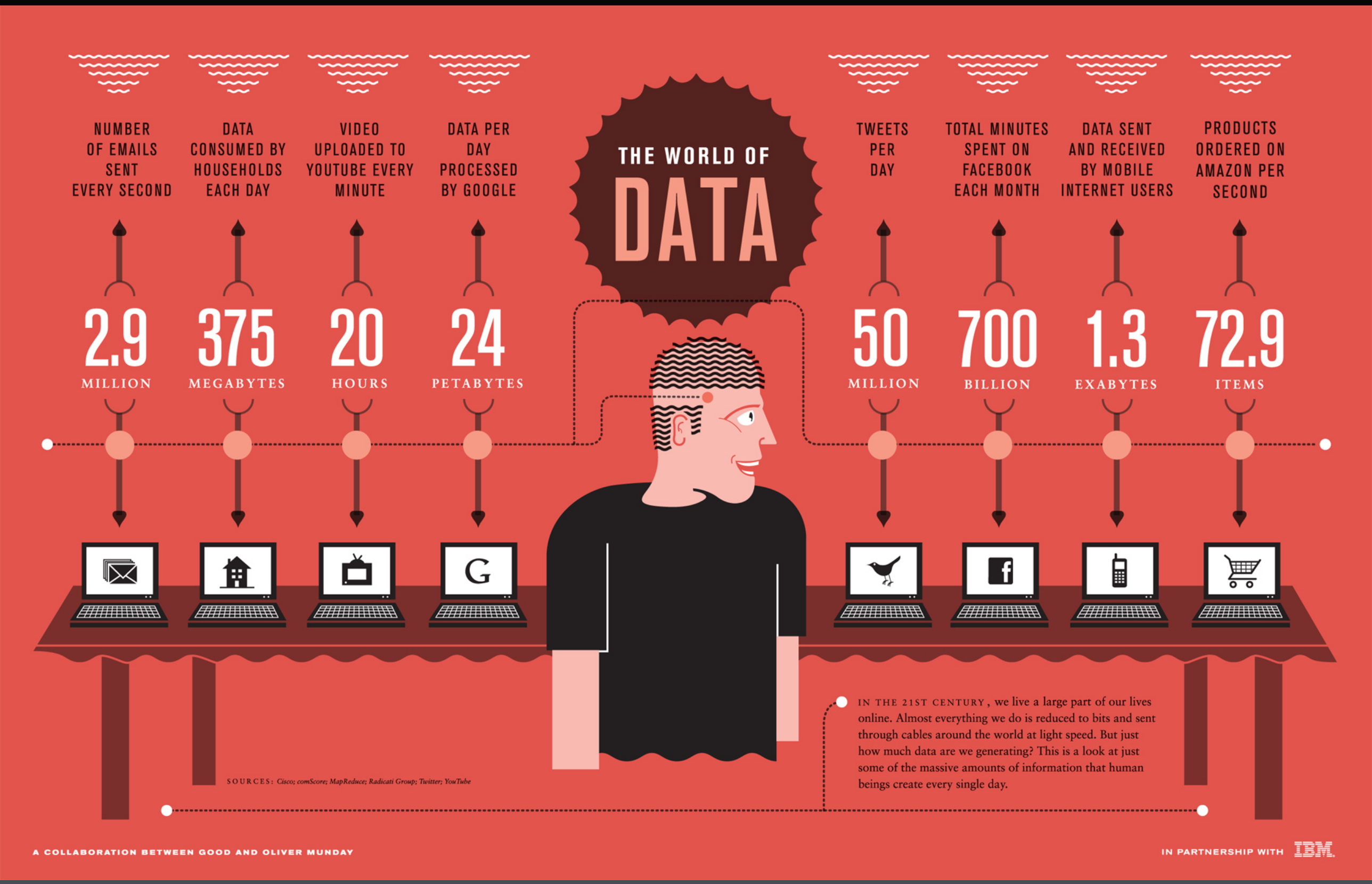
**Polo's definition:**
the *interdisciplinary* science of combining
computation techniques and
interactive visualization
to transform and model data to aid
discovery, decision making, etc.

# What are the “ingredients”?

# What are the “ingredients”?

Need to worry (a lot) about: storage, complex system design, scalability of algorithms, visualization techniques, interaction techniques, statistical tests, etc.

Wasn’t this complex before this big data era. Why?




http://spanning.com/blog/choosing-between-storage-based-and-unlimited-storage-for-cloud-data-backup/

# What is **big data**? Why care?

("big data" is buzz word, so is "IoT" - Internet of Things)

- **Many companies**' businesses are based on big data (Google, Facebook, Amazon, Apple, Symantec, LinkedIn, and many more)
- **Web search**
  - Rank webpages (PageRank algorithm)
  - Predict what you're going to type
- **Advertisement** (e.g., on Facebook)
  - Infer users' interest; show relevant ads
  - Infer what you like, based on what your friends like
- **Recommendation systems** (e.g., Netflix, Pandora, Amazon)
- Online education
- Health IT: patient records (EMR)
- Bio and Chemical modeling:
- Finance
- Cybersecruity
- Internet of Things (IoT)

# Good news! Many jobs!

**Most companies are looking for "data scientists"**

*The data scientist role is critical for organizations looking to extract insight from information assets for 'big data' initiatives and requires a broad combination of skills that may be fulfilled better as a team*
- Gartner (http://www.gartner.com/it-glossary/data-scientist)

Breadth of knowledge is important.

This course helps you learn some important skills.

# Analytics Building Blocks

Collection

Cleaning

Integration

Analysis

Visualization

Presentation

Dissemination

# Building blocks, not “steps”

Collection

Cleaning

Integration

Analysis

Visualization

Presentation

Dissemination

- **Can skip some**
- **Can go back (two-way street)**
- Examples
  - Data types inform visualization design
  - Data informs choice of algorithms
  - Visualization informs data cleaning (dirty data)
  - Visualization informs algorithm design (user finds that results don’t make sense)

# Schedule

Collection

Cleaning

Integration

Analysis

Visualization

Presentation

Dissemination

# Course Goals

- Learn **visual** and **computation** techniques and tools, for typical data types
- Learn how to **complement** each kind of methods
- Work on **real data & problem**
- Learn **practical** know-how (useful for jobs, research)
- Gain **breath** of knowledge

# Grading

- [50%] 4 homework assignments
  - End-to-end analysis
  - Techniques (computation and vis)
  - “Big data” tools, e.g., Hadoop, Spark, etc.
- [50%] Group project -- 4 to 6 people
- [Bonus points] In-class pop quizzes
  - Each quiz is worth **1% course grade**
- **No exams**

# Policies

Collaborating on homework
Late submission policy

# Working on Homework

While collaboration is allowed for homework assignments, each student **must** write up their own answers. All GT students must observe the honor code. Any suspected plagiarism and academic misconduct will be reported and directly handled by the Office of Student Integrity (OSI).

# WARNING

# You'll be writing a lot of code

**Q:** Is it OK to copy and use code found on the web?
**A:** No

**Q:** Why?
**A:** Here's why…

# Do not plagiarize!

- Using code as reference does not mean copying and pasting that code. Nor does that mean copying in a block of code and then modifying parts of it.
- If you want to use some code for reference, you should go over it, understand what it is doing, and then try to accomplish what it is trying to do **using your own code**. And it's a good practice to cite the the sources (e.g., as part of your code comments).
- The analogy is like how you would write an essay or a speech. You can get inspirations from others, but you should **use your own words**, otherwise it will be considered plagiarism. As I mentioned in class, and in the beginning of every homework, **plagiarism can lead to heavy consequences**.
- http://www.plagiarism.org/plagiarism-101/what-is-plagiarism/

# Late Submissions Policy

- **Homework**: each student has *4 slip days* total. No questions asked.
- **Project**: each team has *3 slip days* total. No questions asked. Slip days may not be used on in-class activities (e.g., proposal presentation, poster presentation, etc.).
- To use slip days, **specify the number of days you have used in the textbox on T-Square** (when you submit your work).
- **Each slip day equals 24 hours.** E.g., if a submission is late for 30 hours, that counts as 2 slip days
- After all slip days are used up, **5% deduction for every 24 hours of delay**. (e.g., 5 points for a 100-point homework)
- We **will not consider late submission of any missing parts** of an homework assignment or project deliverable. To make sure you have submitted everything, download your submitted files to double check.
- No penalties for medical reasons or emergencies. You **must** submit a doctor's note or an official letter explaining the emergency.

# Distance Learning Sections (Q & Q3)

A standard 3-day lag applies to all homework and project deliverables. For project presentation, a group that has DL student member can choose to:

1. Present in class without 3-day lag; or
2. Submit a video presentation with 3-day lag (e.g., screen capture)

# Are You Ready to Take this Course?

- Require **a lot of programming**
  - Needs to learn new languages quickly (e.g., Javascript, Scala)
- HW2 (D3 data vis) is most demanding
  - Javascript + CSS + HTML
- You need to be prepared to **learn many things** in short amount of time
  - **Very common in industry**

# Are You Ready to Take this Course?

The best way to find out is to check out previous semester's homework assignments

- poloclub.gatech.edu/cse6242/2017spring/
- http://poloclub.gatech.edu/cse6242/2016fall/
- http://poloclub.gatech.edu/cse6242/2016spring/

# Prerequisites & Expectation

## For both CSE 6242 (grad) and CX 4242 (undergrad)

Students are expected to complete **significant** programming assignments (homework, project) that may involve higher-level languages or scripting (e.g., Java, R, Matlab, Python, C++, etc.).
Some assignments may involve web programming and D3 (e.g., Javascript, CSS).

**You are expected to quickly learn many new things.** For example, an assignment on Hadoop programming may require you to learn some basic Java and Scala quickly, which should not be too challenging if you already know another high-level language like Python or C++. **Please make sure you are comfortable with this.**

Please take a look at the assignments (homework and project) of the previous offerings of this course, which will give you some idea about the difficulty level of the assignments.

Basic linear algebra, probability knowledge is expected.

e.g., http://poloclub.gatech.edu/cse6242/**2017spring**/

# From Previous Classes…

- Class projects turned into papers at top conferences (KDD, IUI, etc.)
- Projects as portfolio pieces on CV
- Increased job and internship opportunities
  - Former students sent me “thank you” notes

# Aurigo: An Interactive Tour Planner for Personalized Itineraries

**Alexandre Yahi*, Antoine Chassang*, Louis Raynaud*, Hugo Duthil*, Duen Horng (Polo) Chau**
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## ABSTRACT

Planning personalized tour itineraries is a complex and challenging task for both humans and computers. Doing it manually is time-consuming; approaching it as an optimization problem is computationally NP hard. We present Aurigo, a tour planning system combining a recommendation algorithm with interactive visualization to create personalized itineraries. This hybrid approach enables Aurigo to take into account both quantitative and qualitative preferences of the user. We conducted a within-subject study with 10 participants, which demonstrated that Aurigo helped them find points of interest quickly. Most participants chose Aurigo over Google Maps as their preferred tools to create personalized itineraries. Aurigo may be integrated into review websites or social networks, to leverage their databases of reviews and ratings and provide better itinerary recommendations.

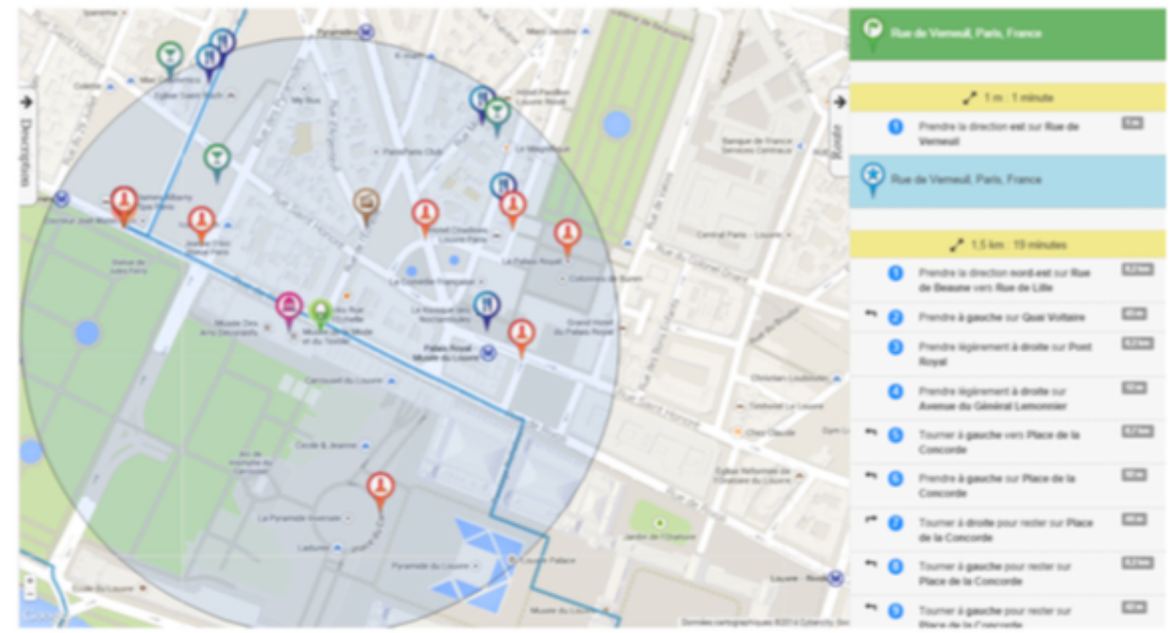
## Author Keywords

User Interfaces; Visualization; Recommendation; Tour itinerary planning

## ACM Classification Keywords

(e.g. HCI): User Interfaces

IUI'15 Full conference paper



# ISPARK: Interactive Visual Analytics for Fire Incidents and Station Placement

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## ABSTRACT

In support of helping to reduce the response time of firefighters, and thus deaths, injuries, and property loss due to fires, we introduce ISPARK. The ISPARK system determines where fire stations should be located, analyzes the primary causes of fires, the existing infrastructure, and response times, by using visualizations which show the GIS mapping of fire stations on a dashboard. Incidents and response times are shown as additional layers, with clustering of fire incidents to determine predicted fire station locations, forecasting of fire incidents using regression, causal, infrastructure, and personnel analysis, creating an interactive, multi-faceted method for locating fire stations. A comparison of urban and rural fire incident response times is another dimension of this study. We demonstrate ISPARK's usage and benefits using a publicly available dataset describing 300,000 fire incidents in the states of Massachusetts and Maine. ISPARK is generalizable to other geographic areas


**Figure 1: Screenshot of ISPARK showing actual (pink) and predicted (green) fire station locations n Maine determined by our approach, using coordiates with actual driving distances from fire stations o actual fire incidents. Fire incidents are shown as small yellow dots. ISPARK reduces the average**

KDD'15 Workshop paper

## Categories and Subject Descriptors

# PASSAGE: A Travel Safety Assistant With Safe Path Recommendations For Pedestrians

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IUI'16 Poster paper

## Abstract

Atlanta has consistently ranked as one of the most dangerous cities in America with over 2.5 million crime events recorded within the past six years. People who commute by walking are highly susceptible to crime here. To address this probl has developed a mobile application, PASSAG d crime data to find "safe pat Atlanta. user int

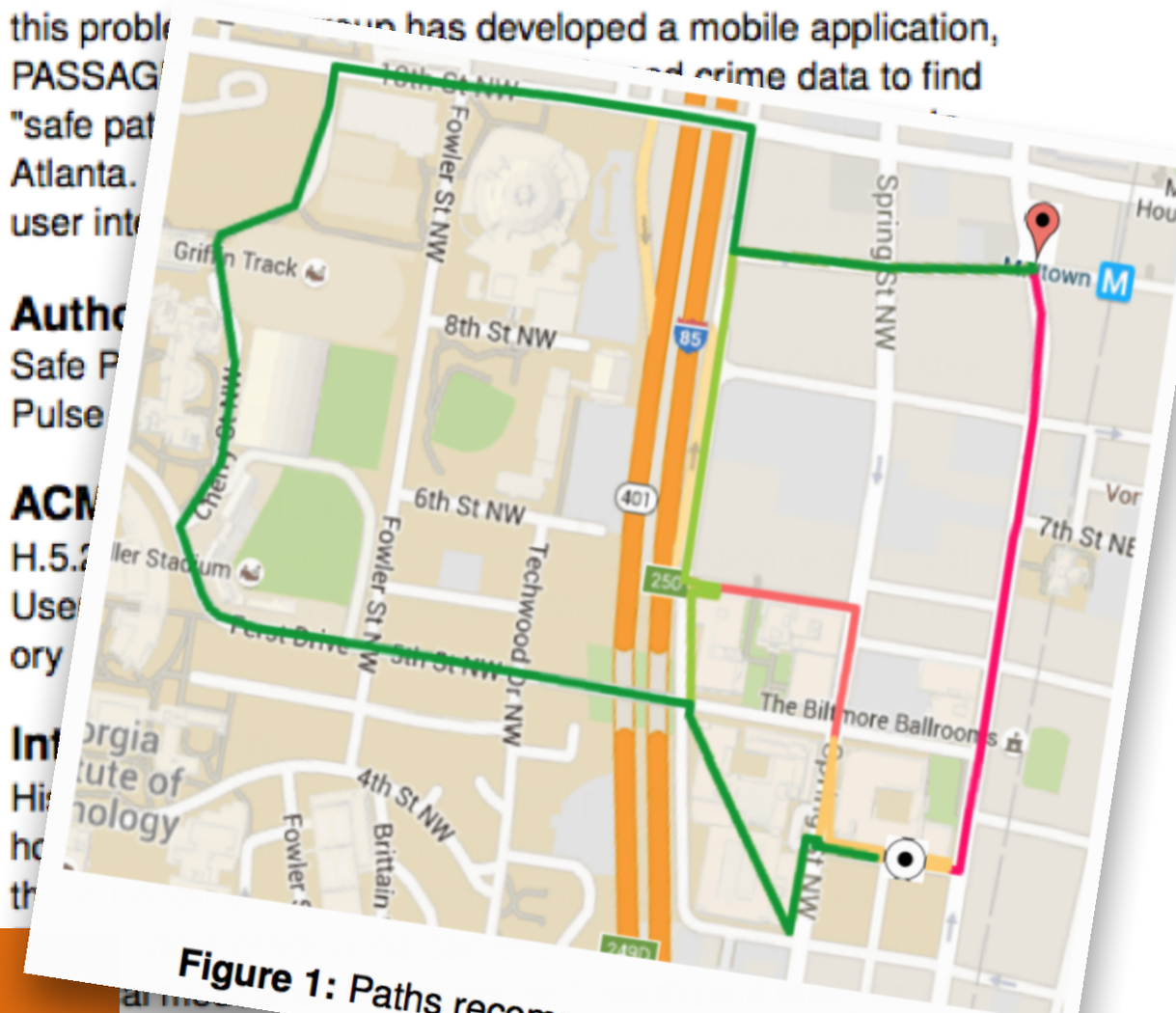


**Figure 1:** Paths recommended by PASSAGE

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made on social media

**Data Science for Social Good, Atlanta** summer program, **http://dssg-atl.io**

# KDD'16 Best Student Paper, runner up

## Firebird: Predicting Fire Risk and Prioritizing Fire Inspections in Atlanta


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### ABSTRACT

The Atlanta Fire Rescue Department (AFRD), like many municipal fire departments, actively works to reduce fire risk by inspecting commercial properties for potential hazards and fire code violations. However, AFRD's fire inspection practices relied on tradition and intuition, with no existing data-driven process for prioritizing fire inspections or identifying new properties requiring inspection. In collaboration with AFRD, we developed the *Firebird* framework to help municipal fire departments identify and prioritize commercial property fire inspections, using machine learning, geocoding, and information visualization. Firebird computes fire risk scores for over 5,000 buildings in the city,


*"I feel like the concepts from your class are like a* ***rite of passage for an aspiring data scientist****. Assignments lead to a feelings of accomplishment and truly progressing in my area of passion."*

*"I really get more intuition about how to* ***deal with data with some powerful tools in HW3*** *[uses AWS]. That feeling is beyond description for me."*

*"I would like to say thank you for your class! Thanks to the skills I got from the class and the project,* ***I got the offer****."*

# What Polo expects from you

- Actively participate throughout the course!
- Ask questions **during class** and on **Piazza**
- Help out whenever you can, e.g., help answer questions on Piazza
- Polo reserves last 5-10min of every class for Q&A

# **FREE** After-class Coffee 

- After each class, starting next week, Polo randomly selects 5 students (+2 volunteers) for **FREE** after-class coffee
- Polo's treat. You can order coffee, tea, pastries — whatever you want
- Very casual — you can ask me **ANYTHING**