# Applications of Network Science

**Social Networks Analysis and Graph Algorithms**

Prof. Carlos Castillo — https://chato.cl/teach

# Sources

- A. L. Barabási (2016). Network Science – Chapter 01 and Chapter 02

- F. Menczer, S. Fortunato, C. A. Davis (2020). A First Course in Network Science – Chapter 00

- URLs cited in the footer of specific slides

# Networks Science

- **Interdisciplinary**; indeed we often address problems from disciplines other than CS

- **Empirical** and data-driven; it is based on the observation of networks

- Quantitative, mathematical, **computational**

# "Red string" suspect boards

A very common TV trope involves detectives looking at a wall where suspects are connected by red strings
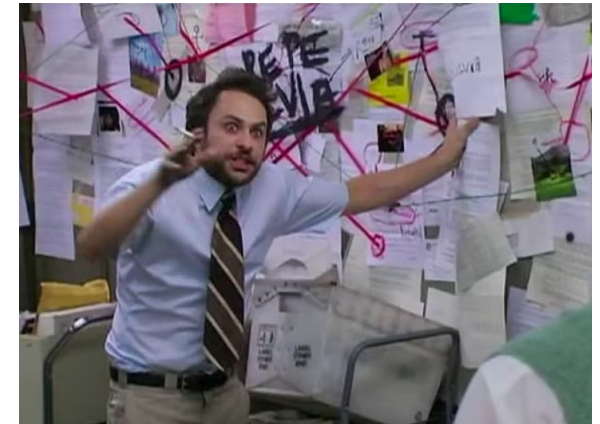
# Help fight

## organized crime and collusion
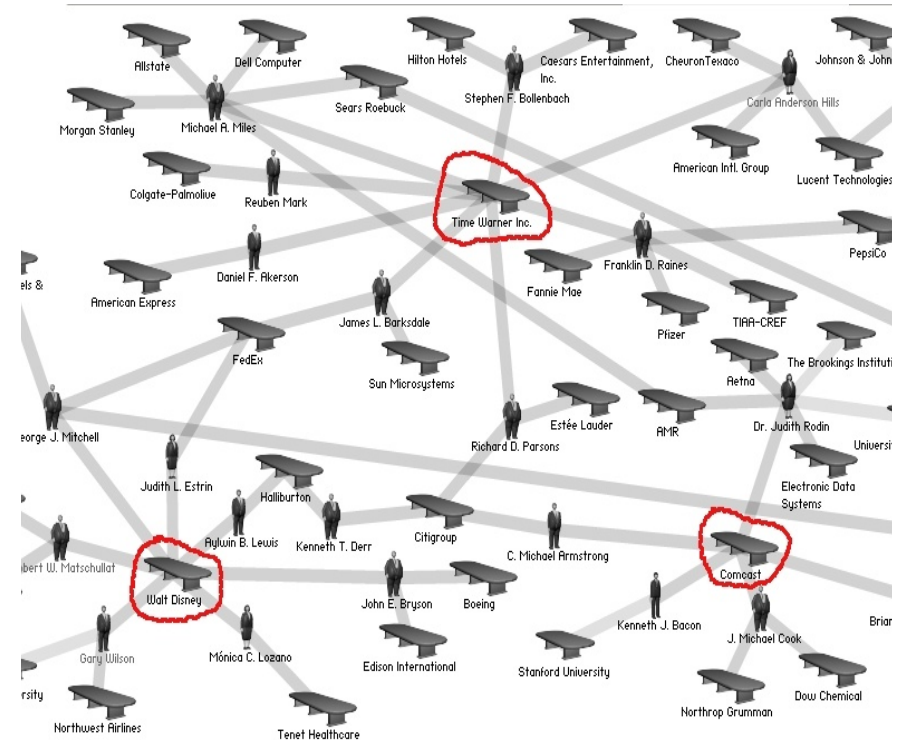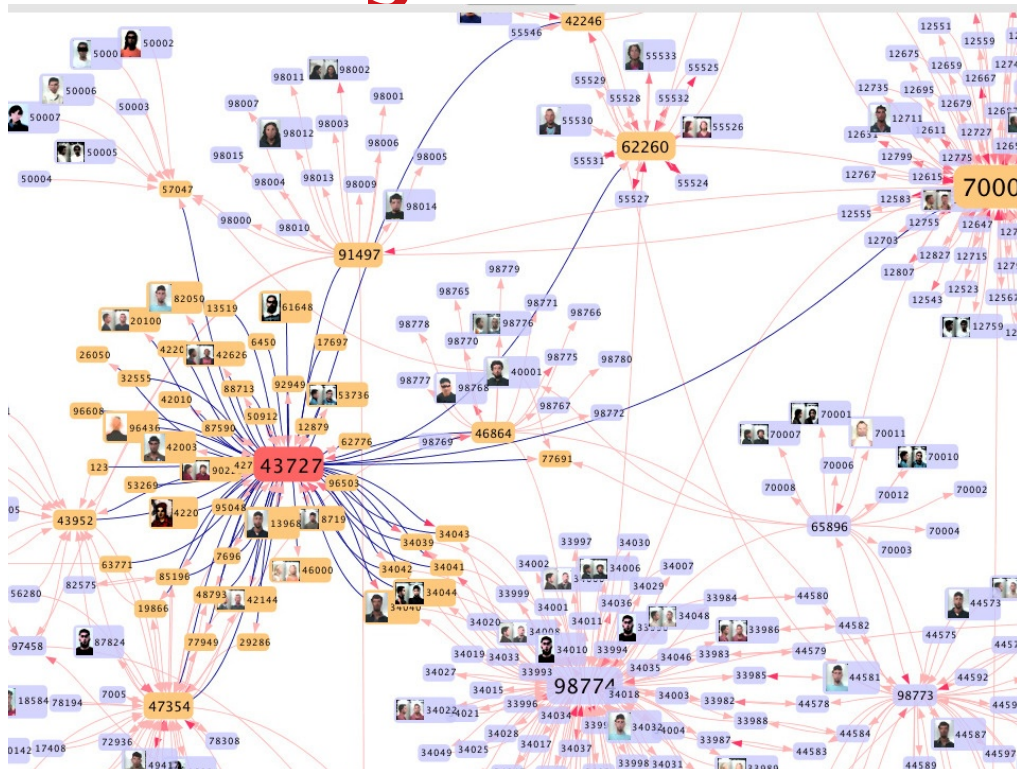
# Help understand political corruption



- 37 corruption cases in Spain in 1989–2018 involving 2,753 people having 27,545 connections

- There are 197 connected components, 58 isolated nodes, and a giant component of 40% of nodes and 53% of edges

- *"empirical results and simulations indicate that **a few recidivist agents** typically play a prominent role in corruption activities. These agents act as **bridges** among minor corrupt groups and possibly engage and coordinate them to work in more extensive and often much more harmful corruption processes to society." (emphasis added)*
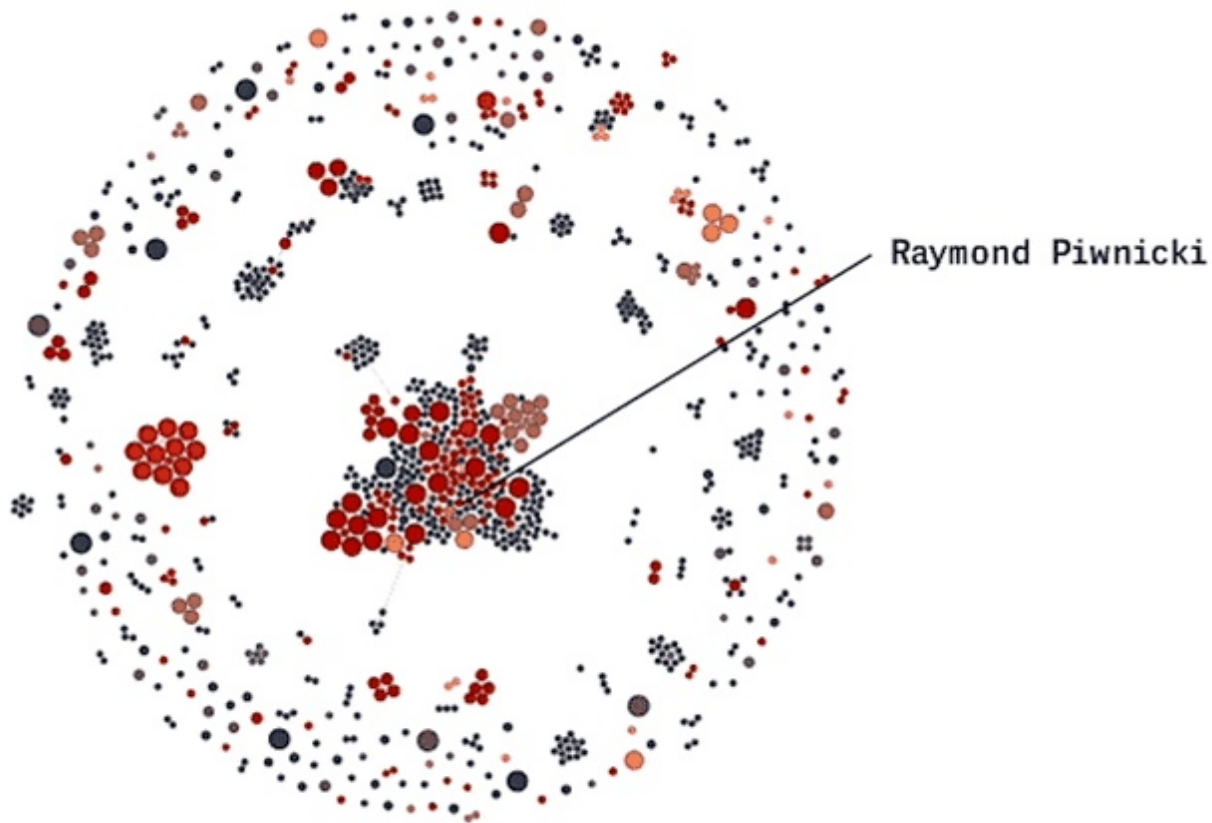
https://www.nature.com/articles/s41598-022-10909-2 based on data from https://casos-aislados.com/

# Help fight police corruption



**The Intercept_**

**BAD CHICAGO COPS SPREAD THEIR MISCONDUCT LIKE A DISEASE**
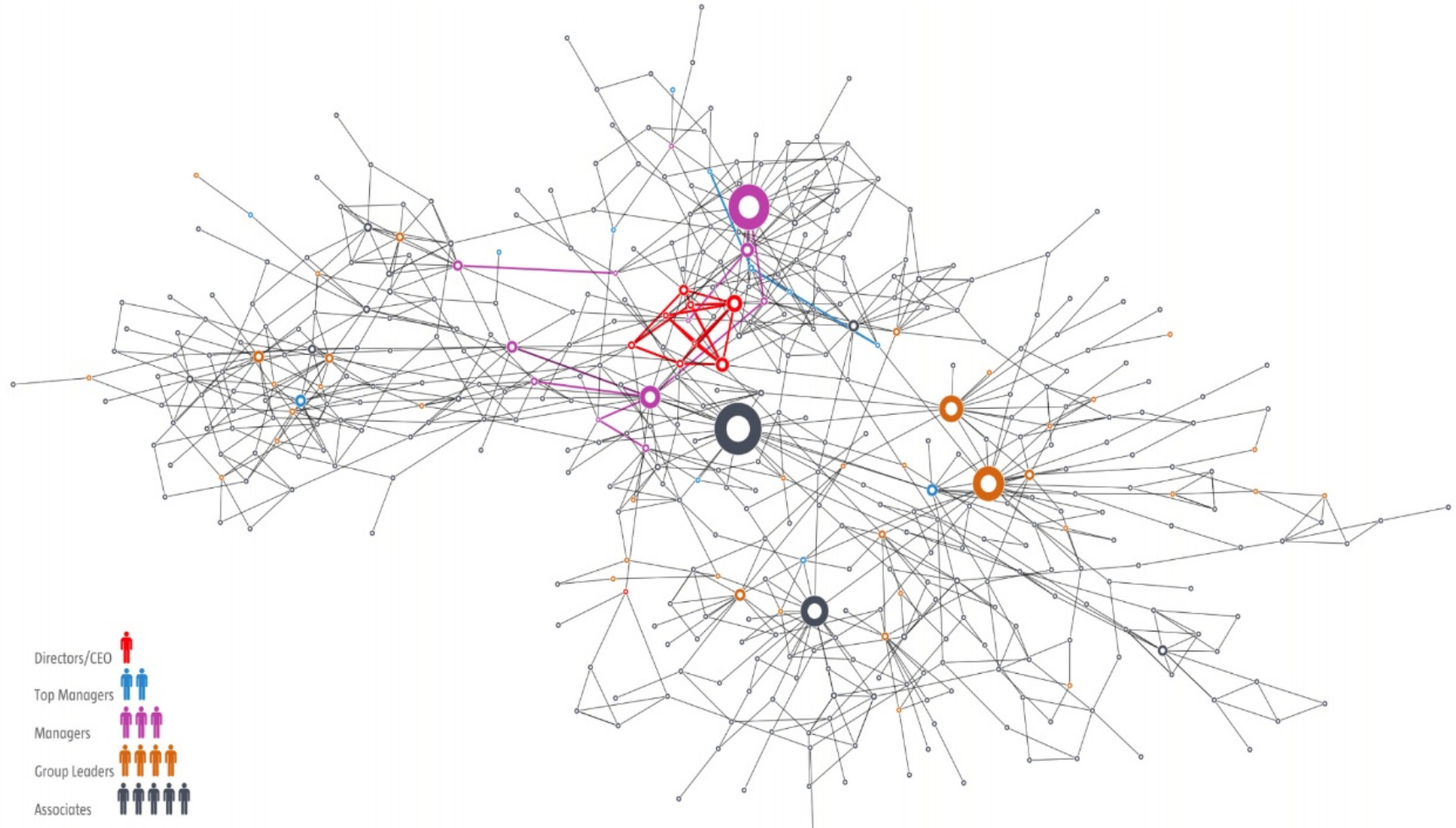
Rob Arthur

August 16 2018, 3:03 p.m.

Raymond Piwnicki

https://theintercept.com/2018/08/16/chicago-police-misconduct-social-network/

# Help to forecast epidemics



https://www.youtube.com/watch?v=mm2u9RKwgsY

# Help understand organization structures



Directors/CEO
Top Managers
Managers
Group Leaders
Associates

# Help improve the communications of an organization

- About 3M e-mails sent or received by an EU research organization address

- Nodes are e-mail addresses (~1K internal, ~250K external)

- Edges are e-mails

https://www.youtube.com/watch?v=4JS-30dglqg

# Help to understand international trade

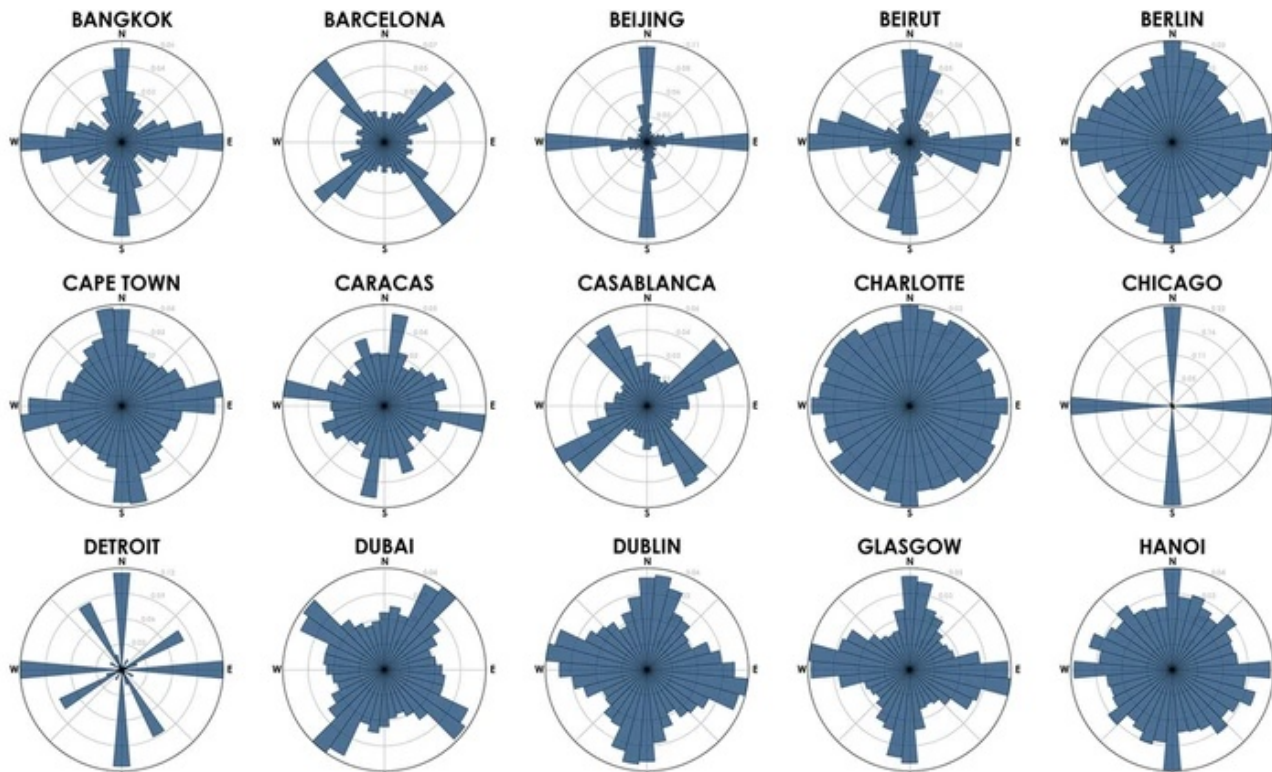Multiple structural, economic, geographical, and political factors affect the global trade network structure.
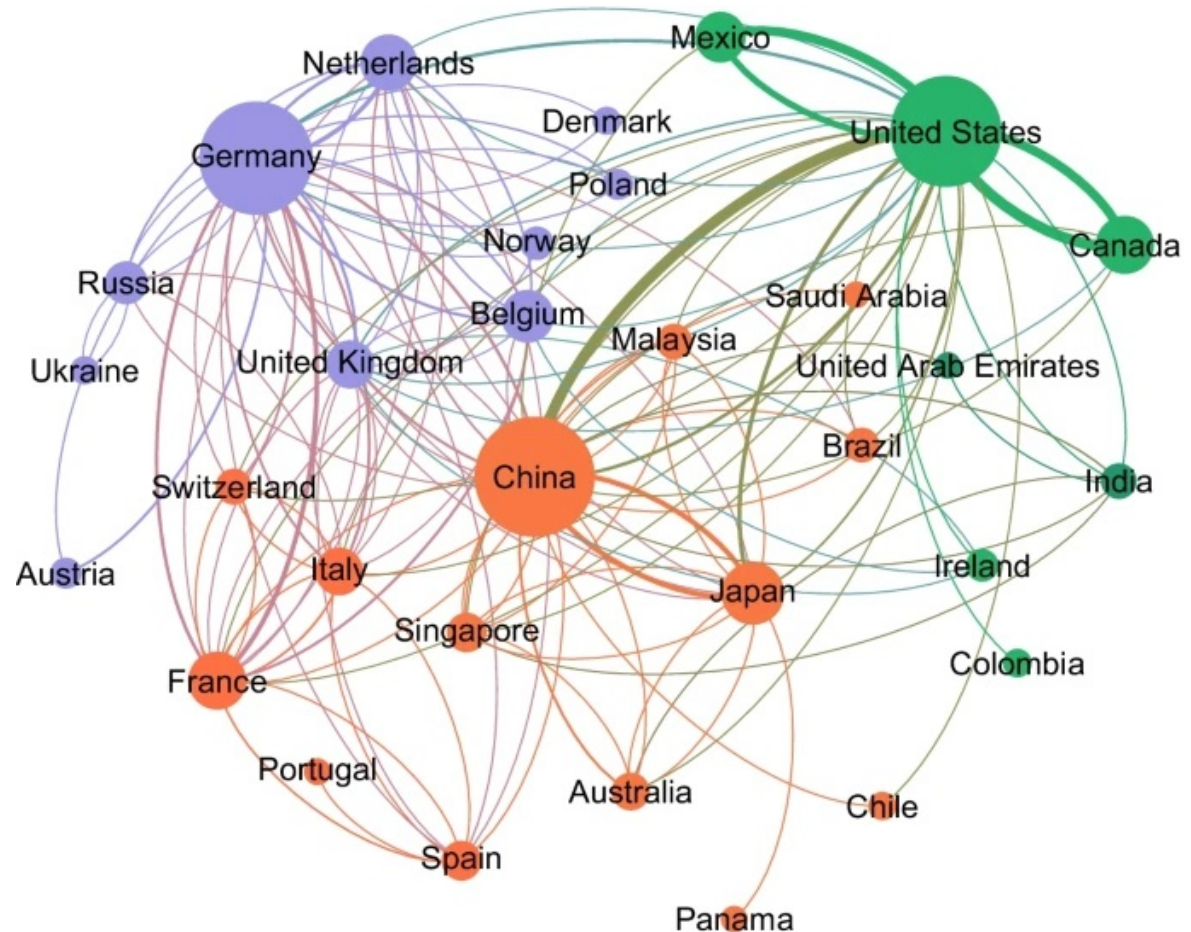
# Fight misinformation and hate online

Inauthetentic accounts a.k.a. "**bots**" are anomalies in terms of connectivity patterns
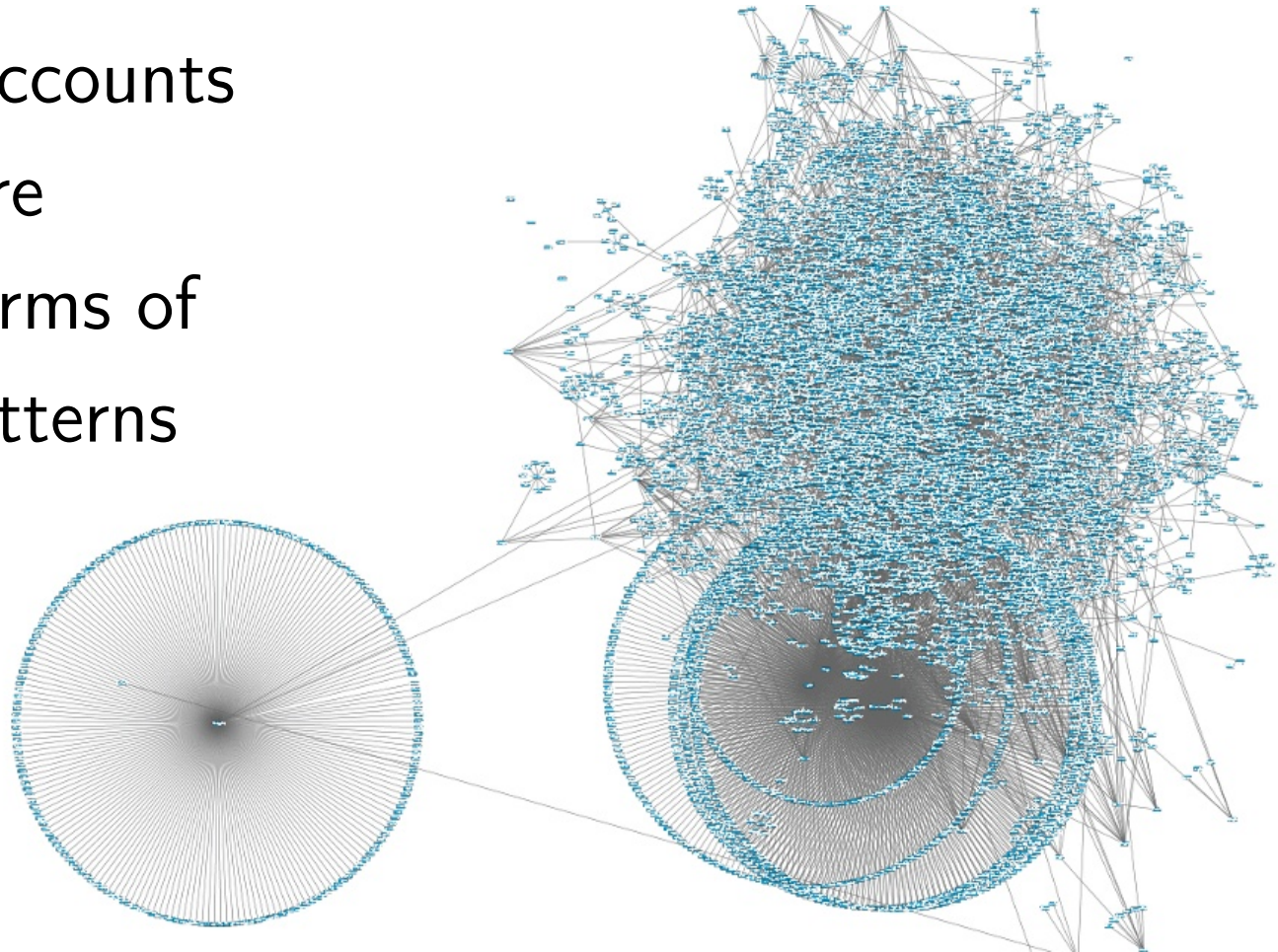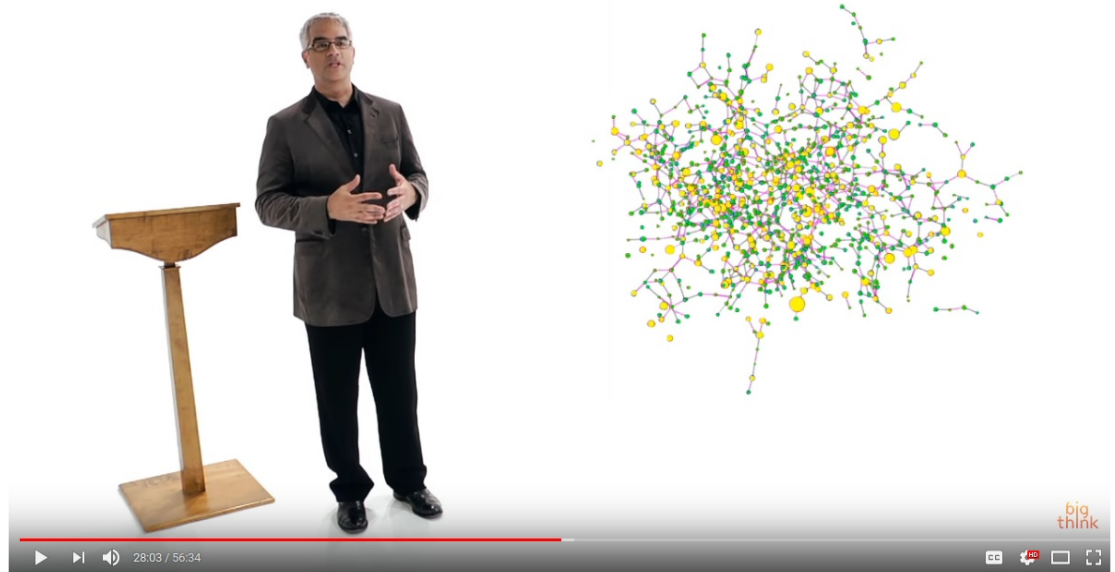
# Improve mobility within cities

City grids have polarities that can be seen through networks analysis.

# Help understand society, diseases, and design new treatments and drugs

Must watch:
Nicholas Christakis (1 hour)

28:03 / 56:34

https://www.youtube.com/watch?v=wadBvDPeE4E

# What we will learn

- To describe a network in formal terms

- To identify it as such and characterize it

- To visualize different networks

- To operate with networks programmatically

- To find important nodes and communities

- To make discoveries or help others make them

- Much more (to a large extent, it's up to you!)

# How we will learn

https://github.com/chatox/networks-science-course/

- Theory sessions:

    - Help you find important nodes, communities, and track influence

    - Help you understand how to model complex networks

    - Do some simple (and not so simple) exercises to check that you understood correctly each concept, and to help you remember

- Practice sessions:

    - Help you work with complex networks

    - Manage and analyze graphs in Python

- My focus is on what I think has value for you as a data scientist

# Summary

# Things to remember

- Applications of complex networks analysis

# Additional contents
# (not included in exams)

# Why network science is important **to me**

# PhD work (2000-2004)

- Collecting web pages

- Characterizing national web domains

  - Chile, Korea, Greece, Spain ...

# Top .es domains
# (~2006)



"GOV"

"COM"

"EDU"

usal

la_moncloa

ub

elmundo

# An influential book (to me)

This book came out in 2002 and made me see networks everywhere; it's an easy read, written for the general public, highly recommended

Its author, Albert-László Barabási visited my university **in Chile** while I was a PhD student :-)
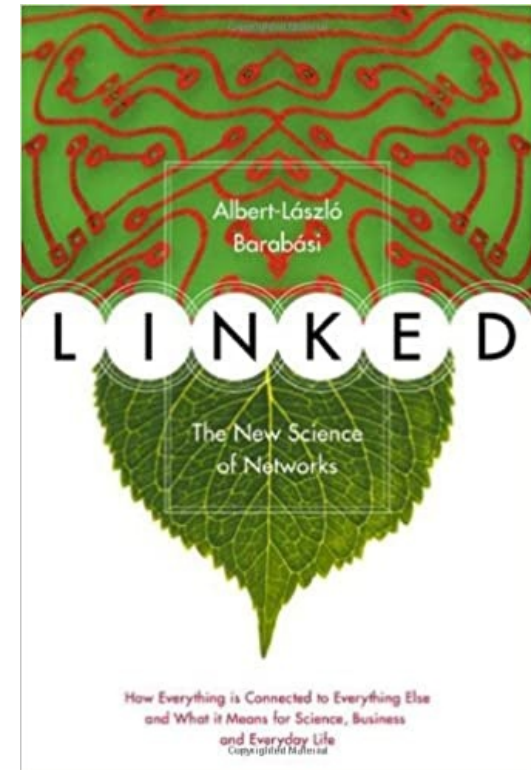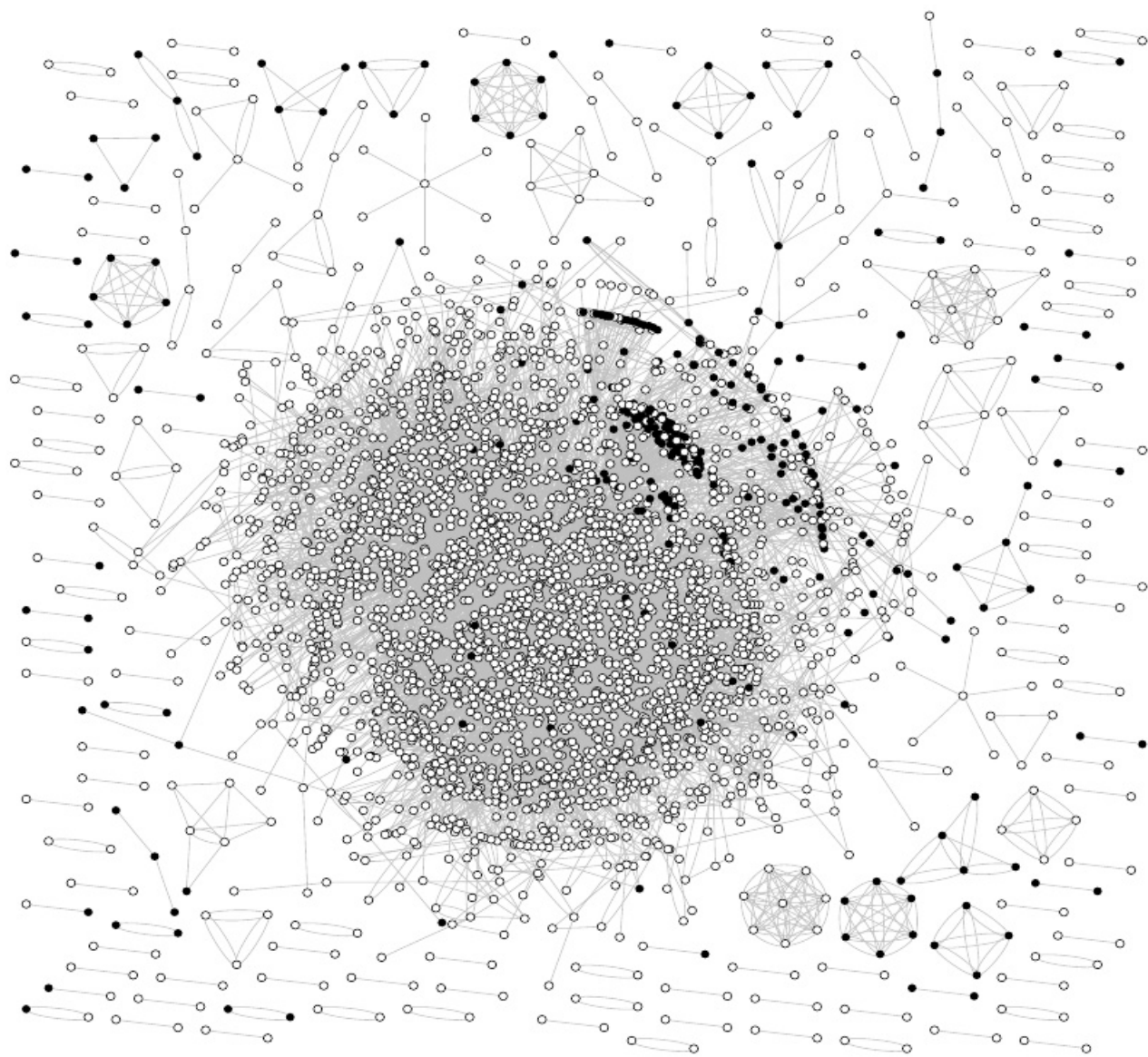
# Early post-doctoral work (~2006-2009)

- Web spam pages

  - Pages created to deceive search engines

  - Attract traffic by stuffing themselves with keywords

  - Increase link score of other pages

  - Methods evolve all the time, how to catch them?

# An Eureka! Moment

2006

Visualization of a web spam dataset using gnuplot; spam nodes (in black) cluster together!
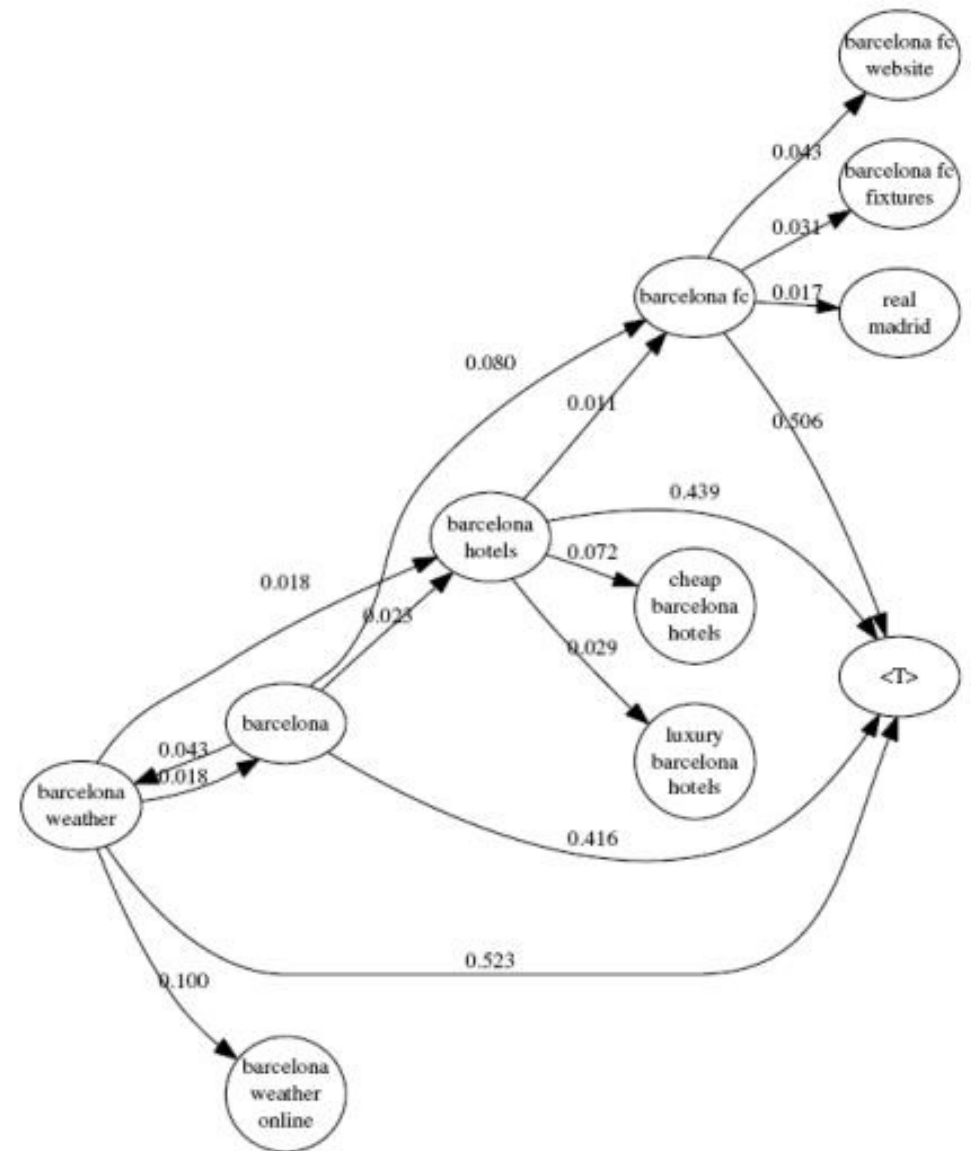
# Query flows

2008

We wonder what is the most likely query before or after another query?

How are they connected? This is how we developed **query flow graphs**

# Graphs in my own work

- Everywhere! — See https://chato.cl/research/

- Currently:

  – part of a larger toolbox

  – skeptical about structural-only conclusions