

Community Structure in Networks

Social Networks Analysis and Graph Algorithms

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Sources

- Barabási 2016 Chapter 9
- Networks, Crowds, and Markets Ch 3
- F. Menczer, S. Fortunato, and C. A. Davis. A First Course in Network Science. Cambridge University Press, 2020. Chapter 6
- C. Castillo: Graph partitioning 2017

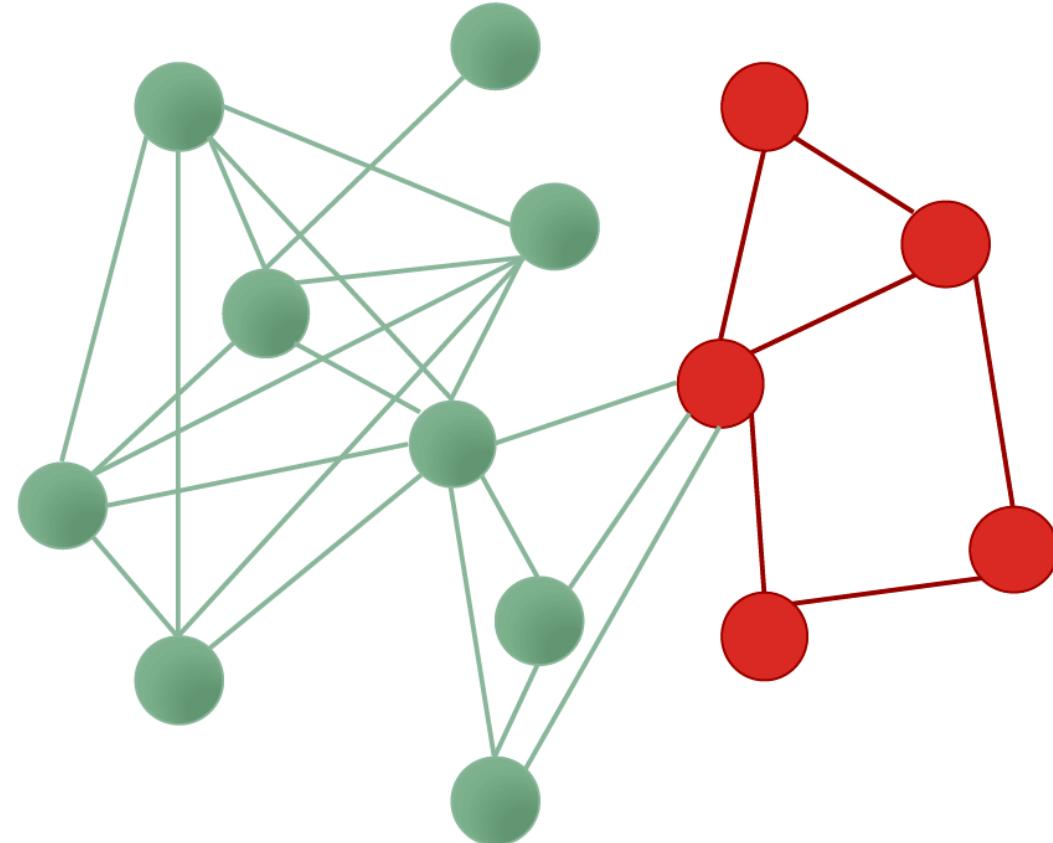
Typical community structures

- One dense sub-graph
 - embedded somewhere within a larger graph
- Two groups (polarization)
 - plus perhaps some ambiguous nodes
- Multiple communities

One dense sub-graph

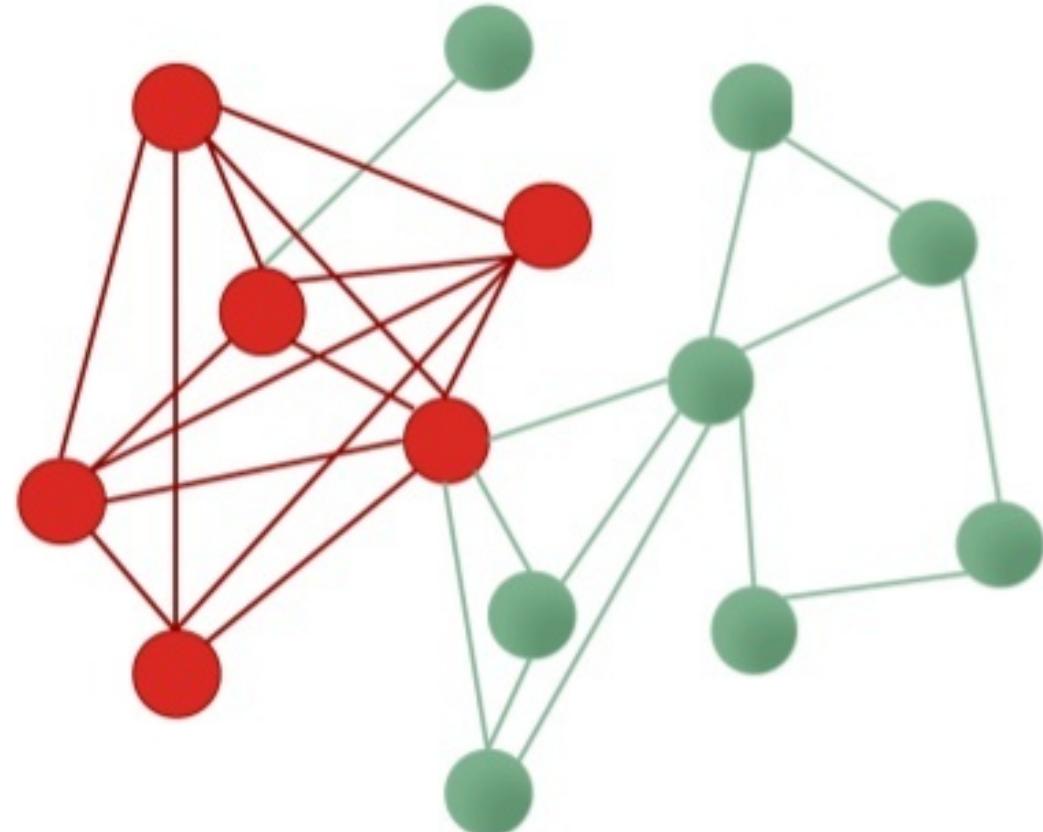
What is a sub-graph?

Subset of nodes,
and edges
among those
nodes



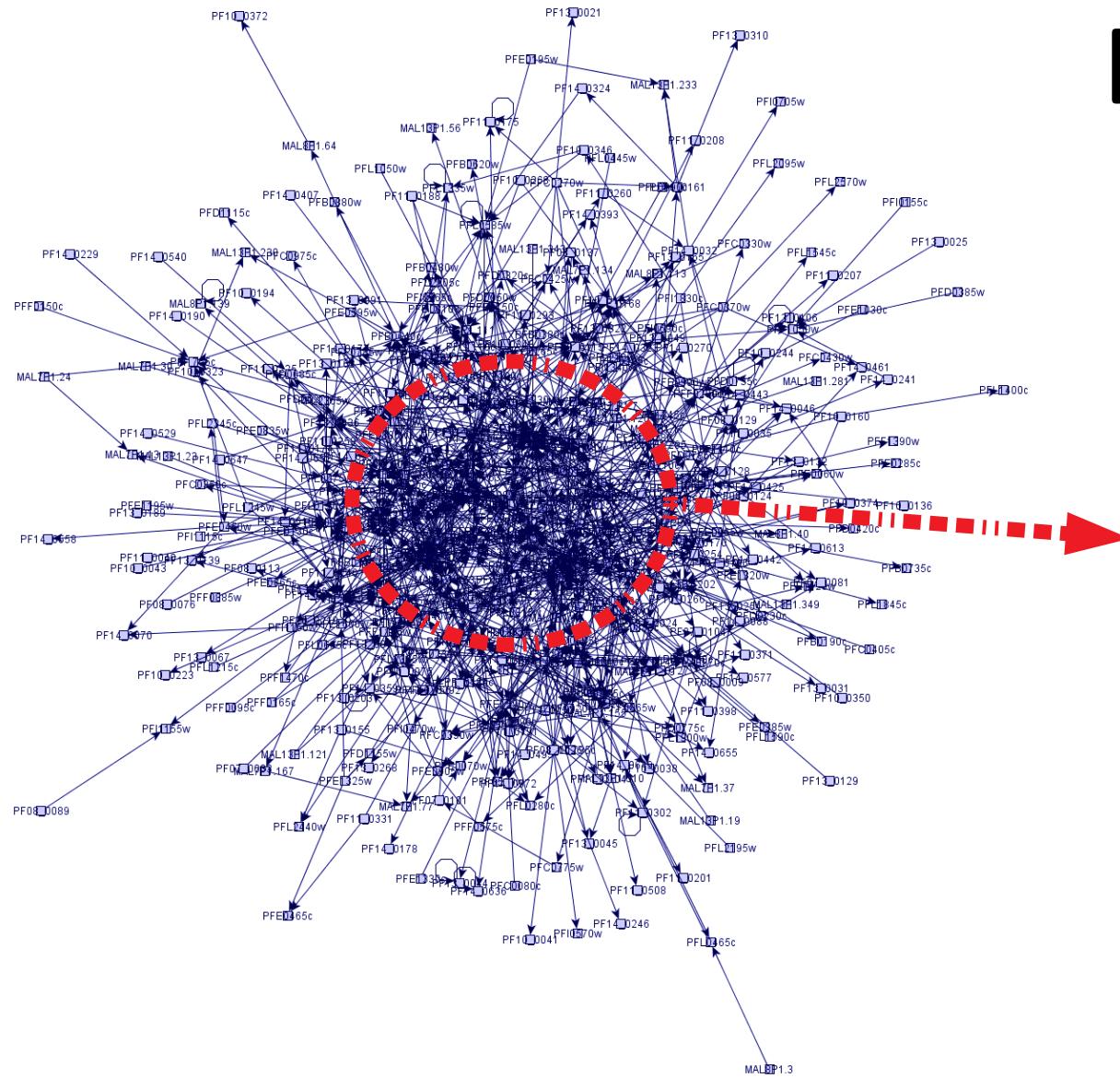
Densest sub-graph

Sub-graph
having the
maximum
density

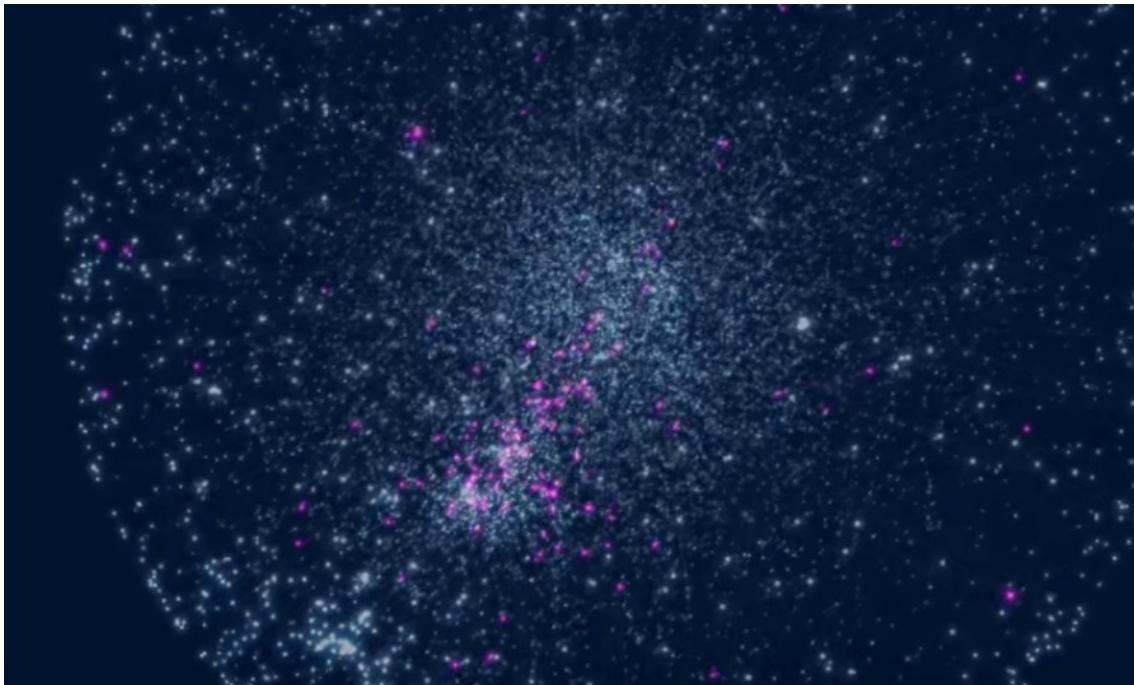


Many graphs look
like “hairballs”

Sometimes, at the center these graphs may have an interesting dense sub-graph



Asthma-related genes



https://www.youtube.com/watch?v=VU_7FHAKMgA

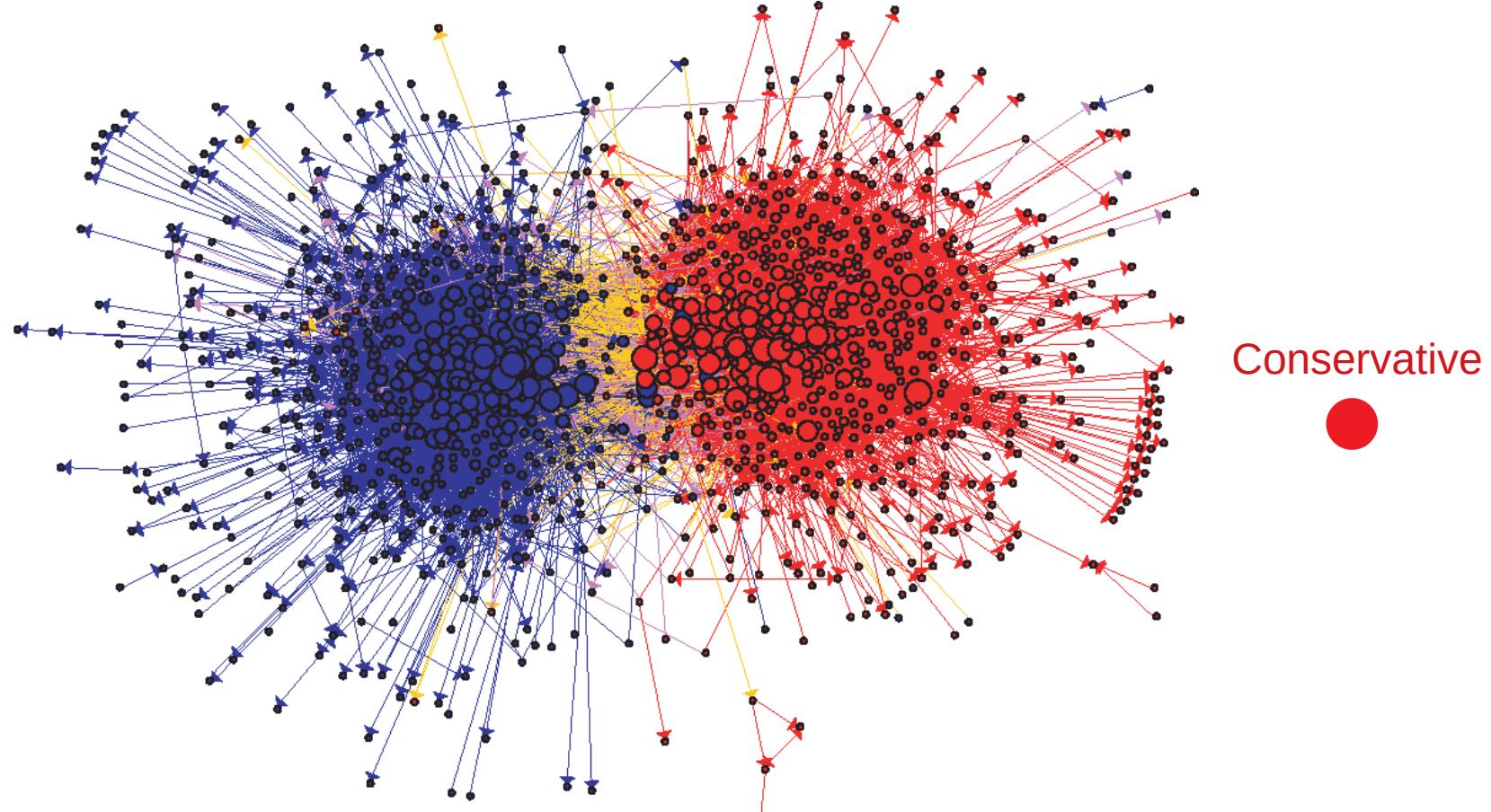
Two groups (polarization)

US Political Blogs (2004)

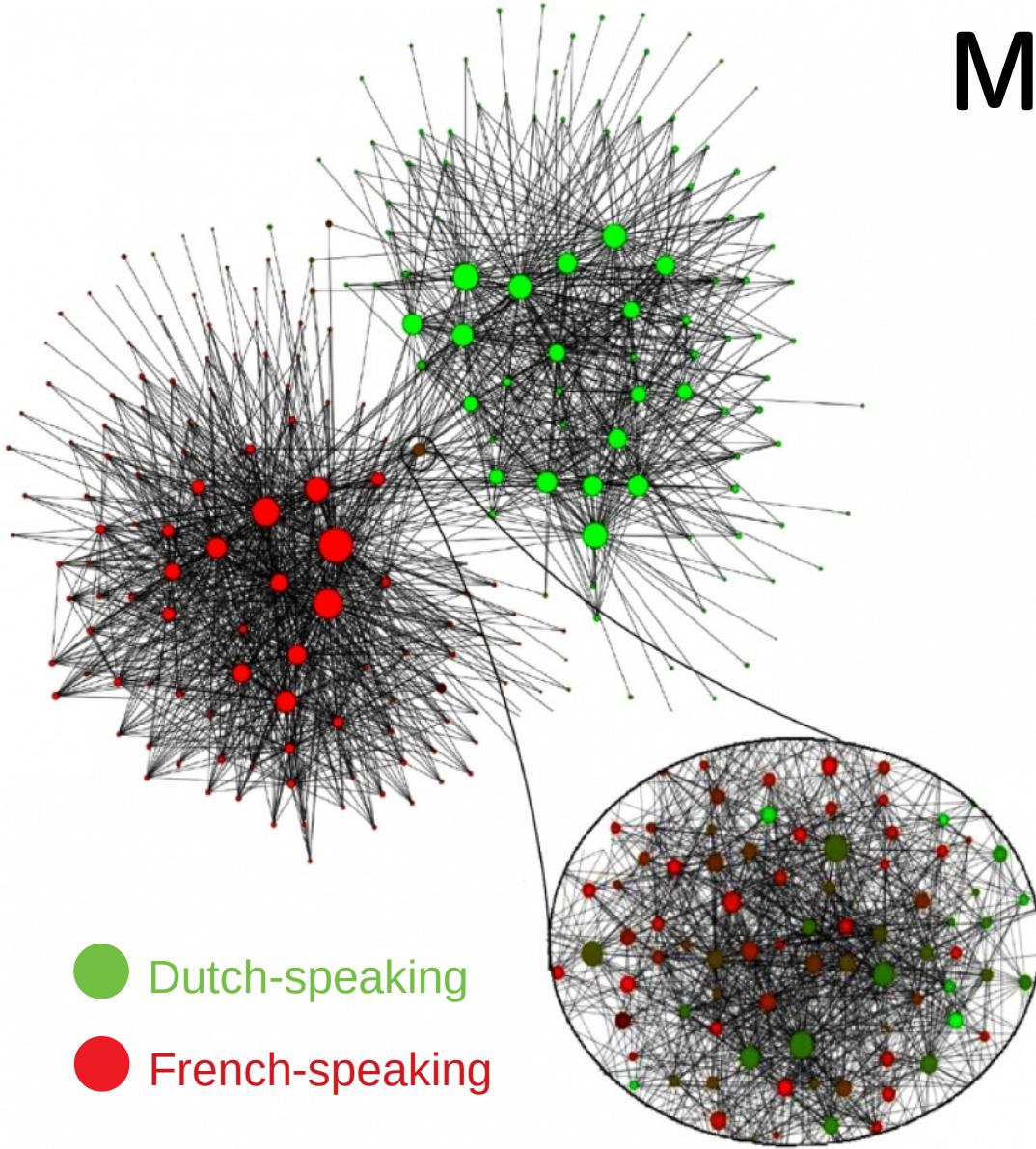
Liberal



Conservative



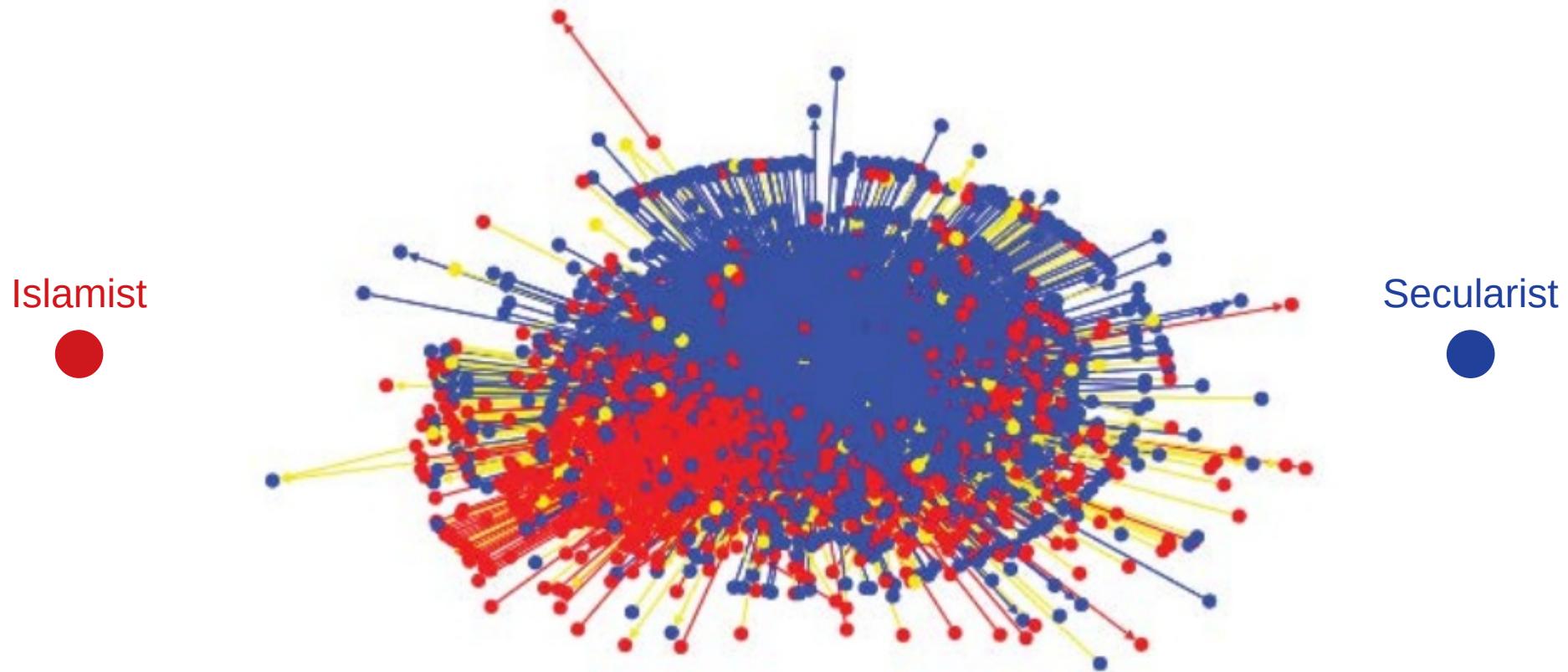
Mobile phone users in Belgium (2008)



Each node is a community of 100 mobile users or more that tend to call each other

V. D. Blondel, J.-L. Guillaume, R. Lambiotte, and E. Lefebvre. Fast unfolding of communities in large networks. *J. Stat. Mech.*, 2008.

Egyptian Twitter Users (2013)



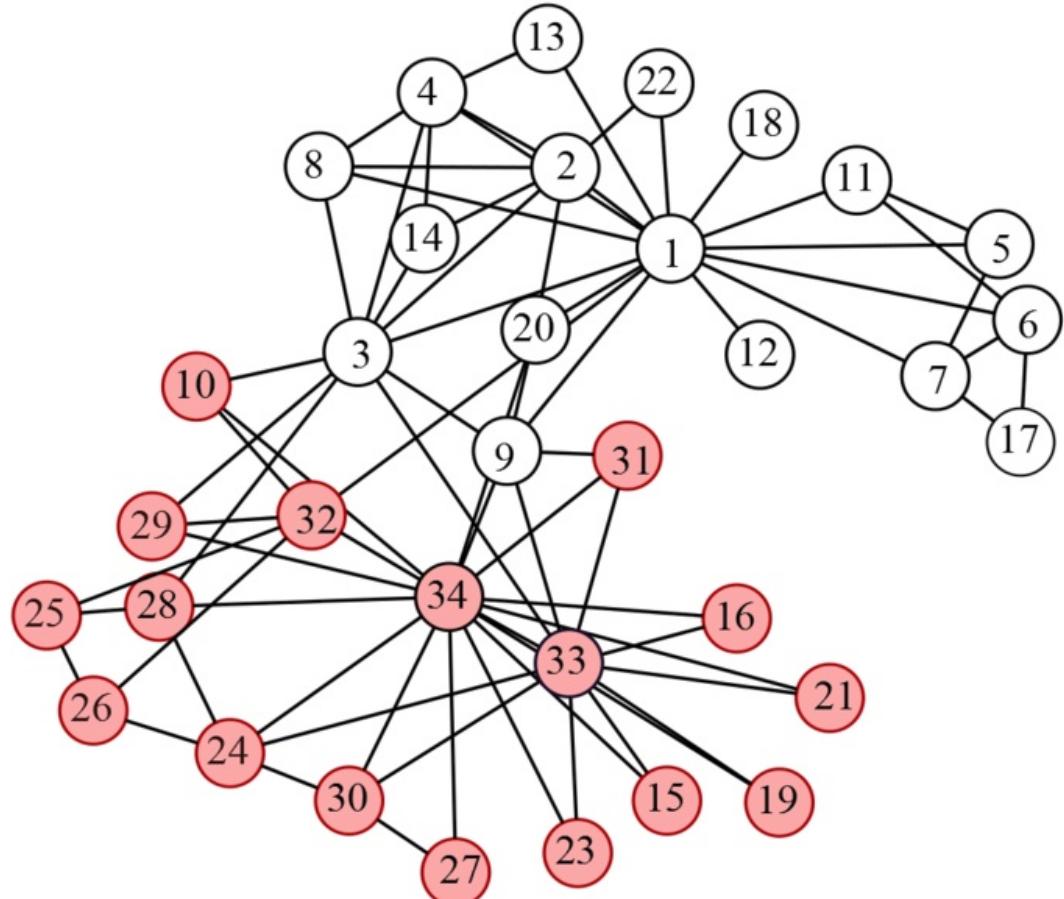
Political Books



Source:
Valdis Krebs
& The Economist

Wayne Zachary's PhD Thesis (1972)

- Studied 34 members of a karate club
- Found 78 links between members who regularly interacted outside the club
- The club splitted in two during the study
- 1=sensei, 34=president



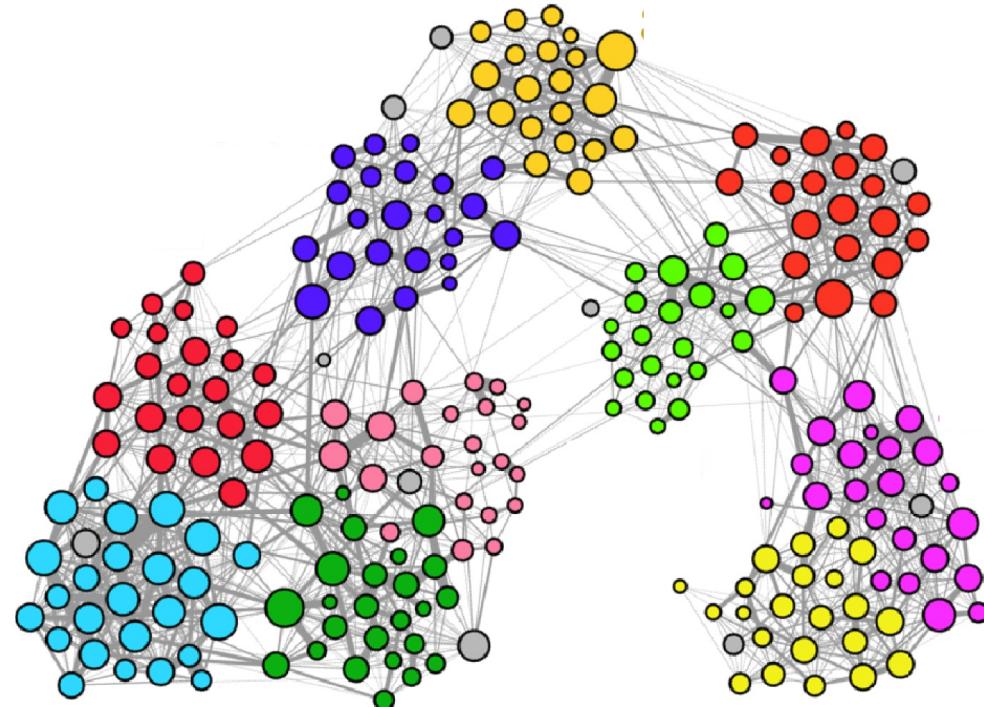
Multiple communities

Primary school contacts

Links connect students who spent more than two minutes facing each other at less than 1.0m-1.5m during one day.

Students wore RF-ID badges hanging on their chest.

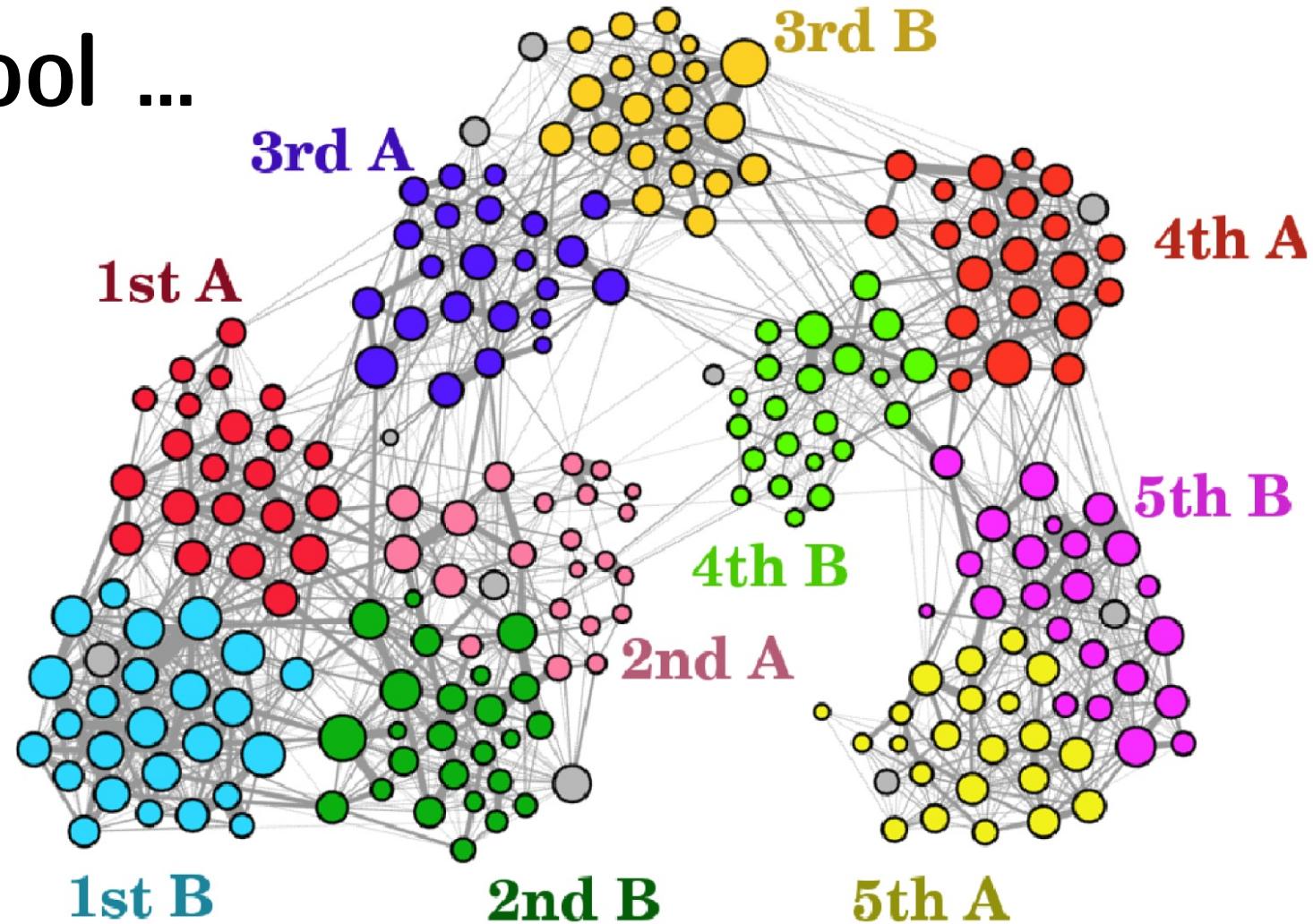
What do you think the colors represent in this visualization?



Primary school ...

Colors represent classes. Teachers are shown in gray color.

Node sizes are number of connections.



Stehlé, J., et al. (2011).

High-resolution measurements of face-to-face contact patterns in a primary school.

PloS one, 6(8), e23176.

Science

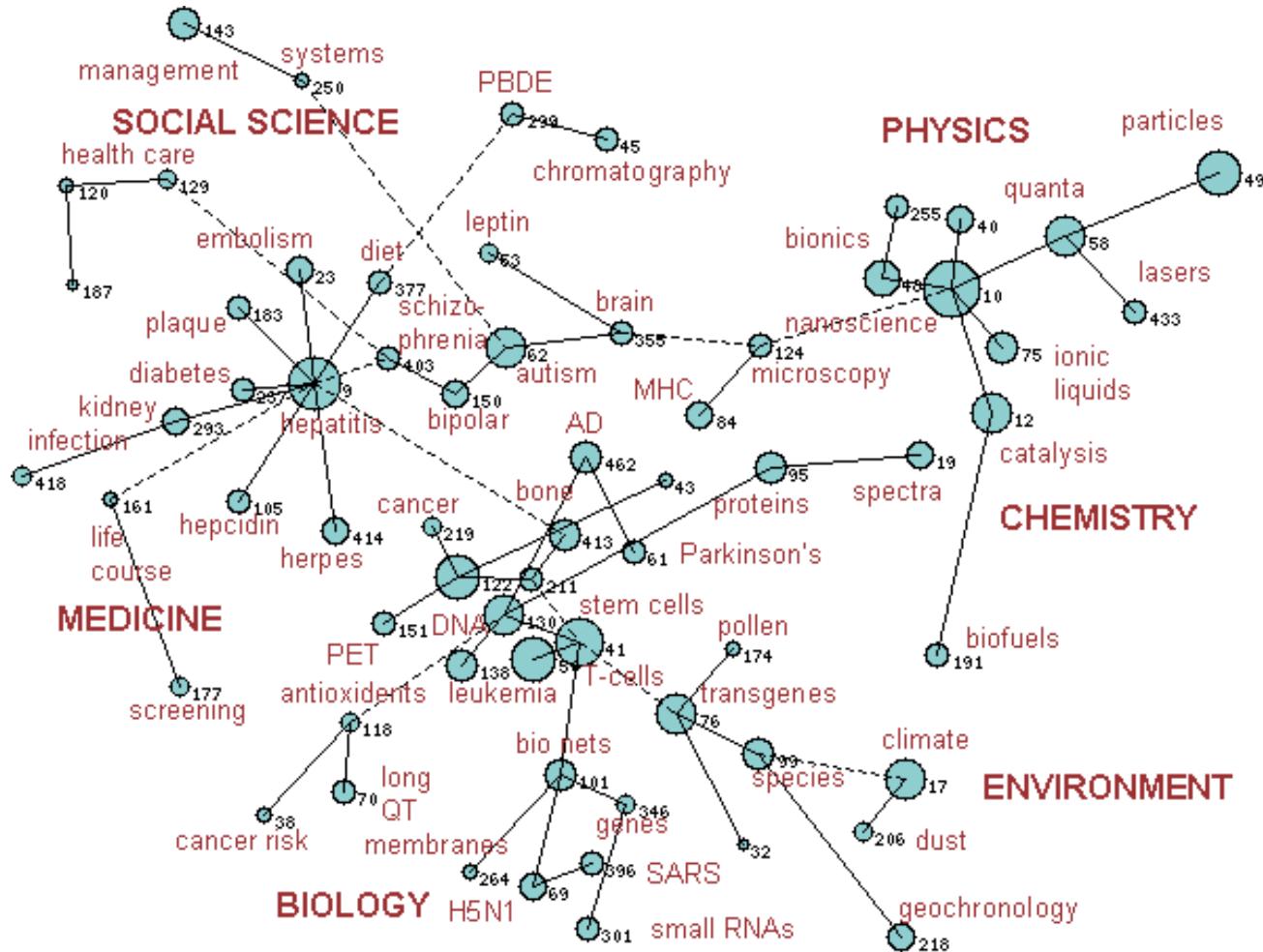
Two topics T_1 , T_2 , are

connected if there is at least

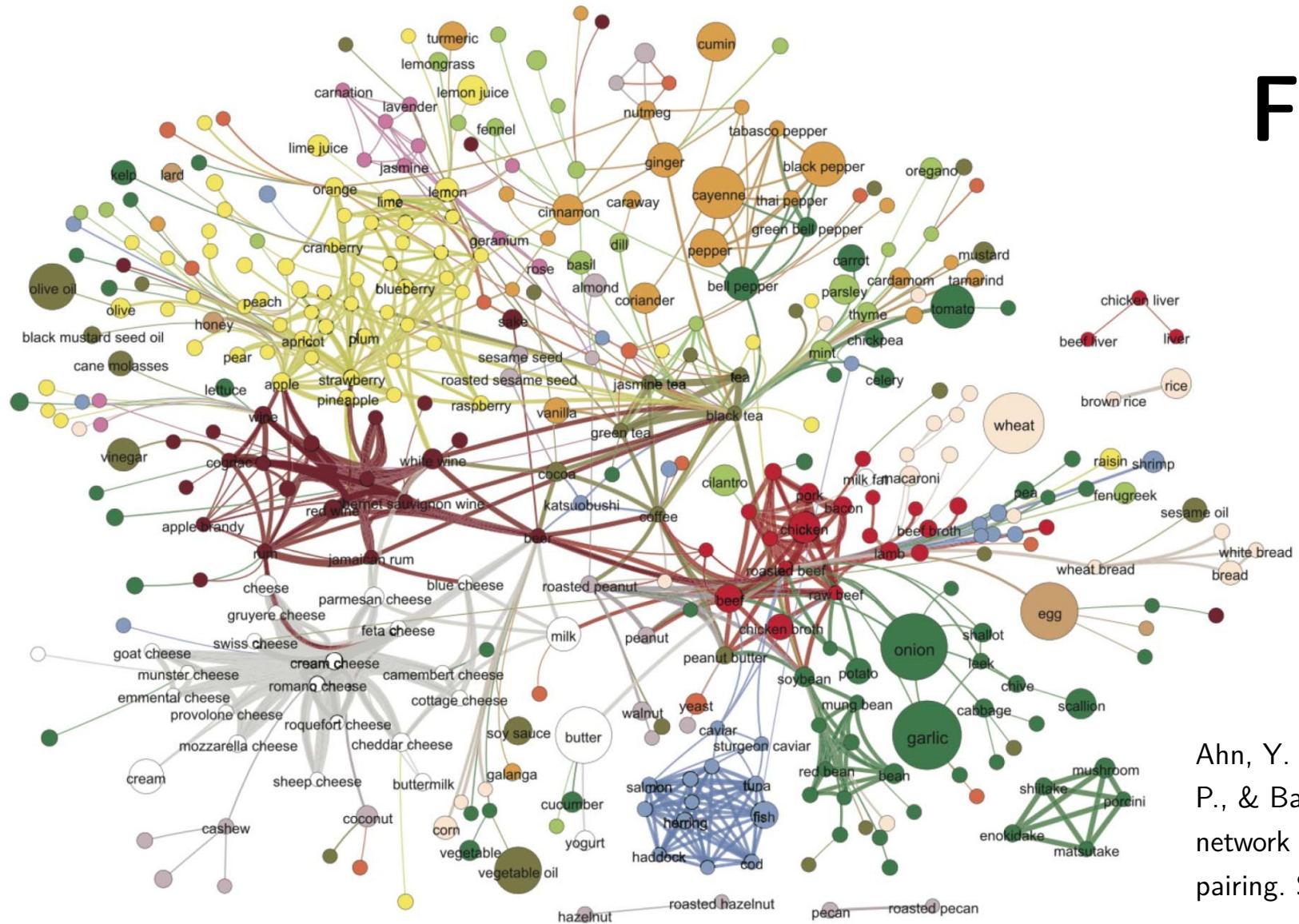
one paper that cites:

a paper u in T_1 and

a paper v in T_2 .

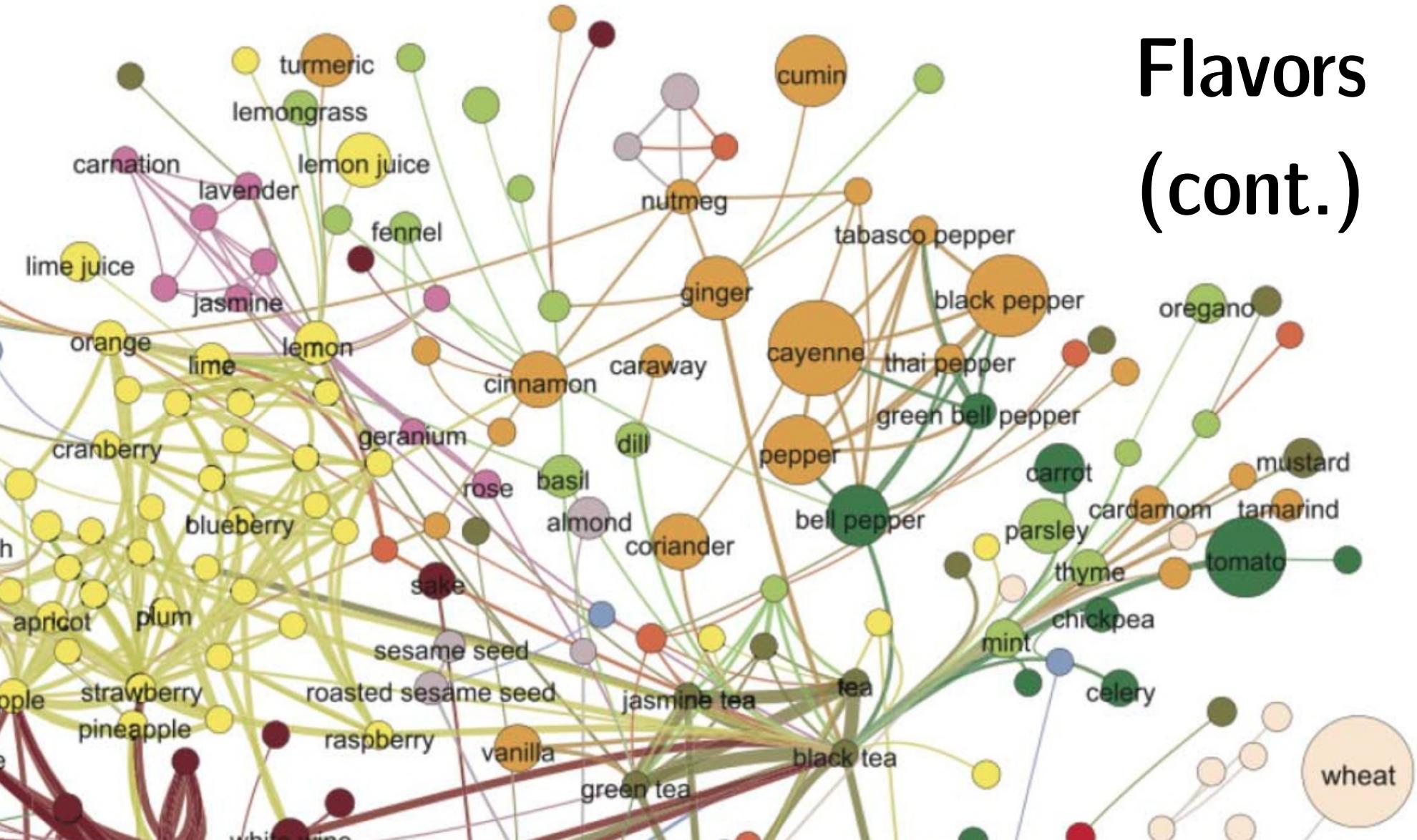


Flavors

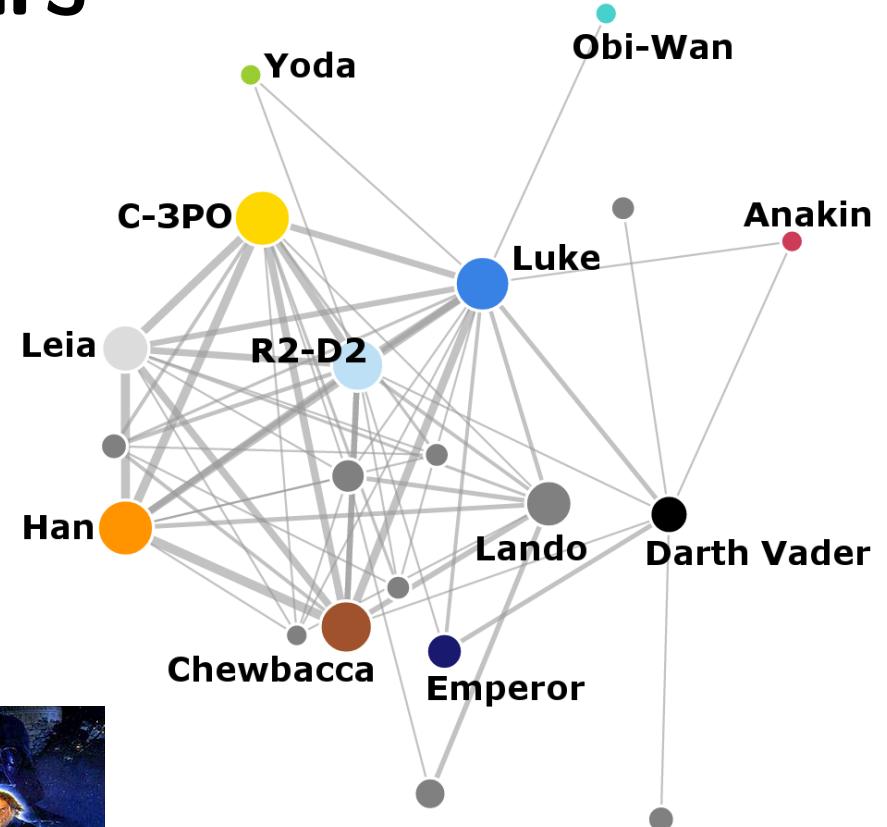
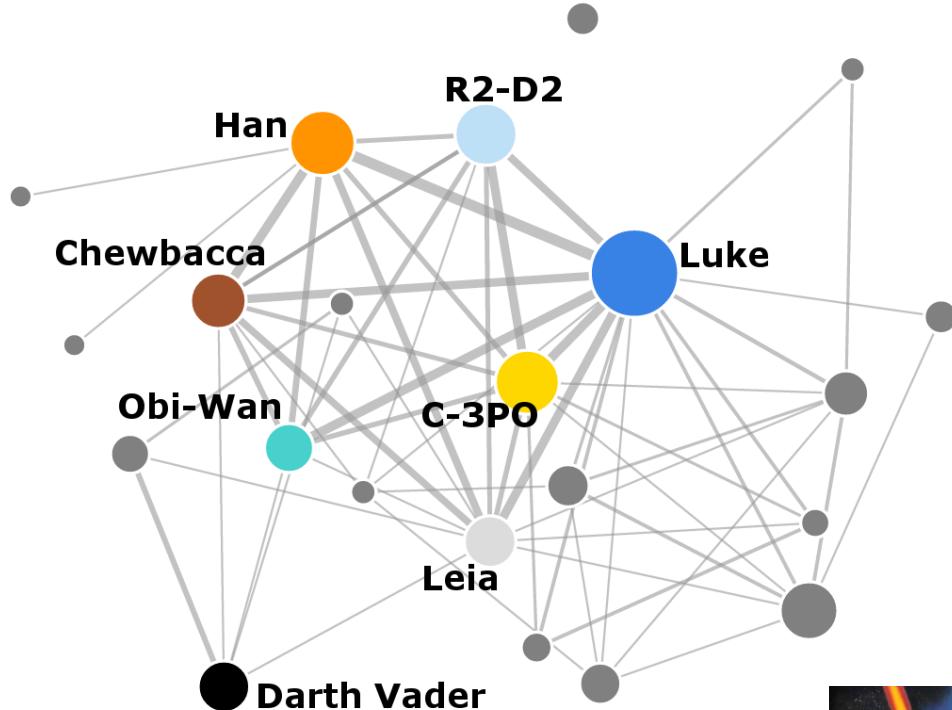


Ahn, Y. Y., Ahnert, S. E., Bagrow, J. P., & Barabási, A. L. (2011). Flavor network and the principles of food pairing. *Scientific reports*, 1, 196.

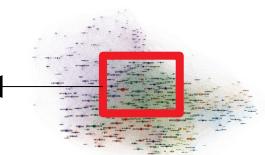
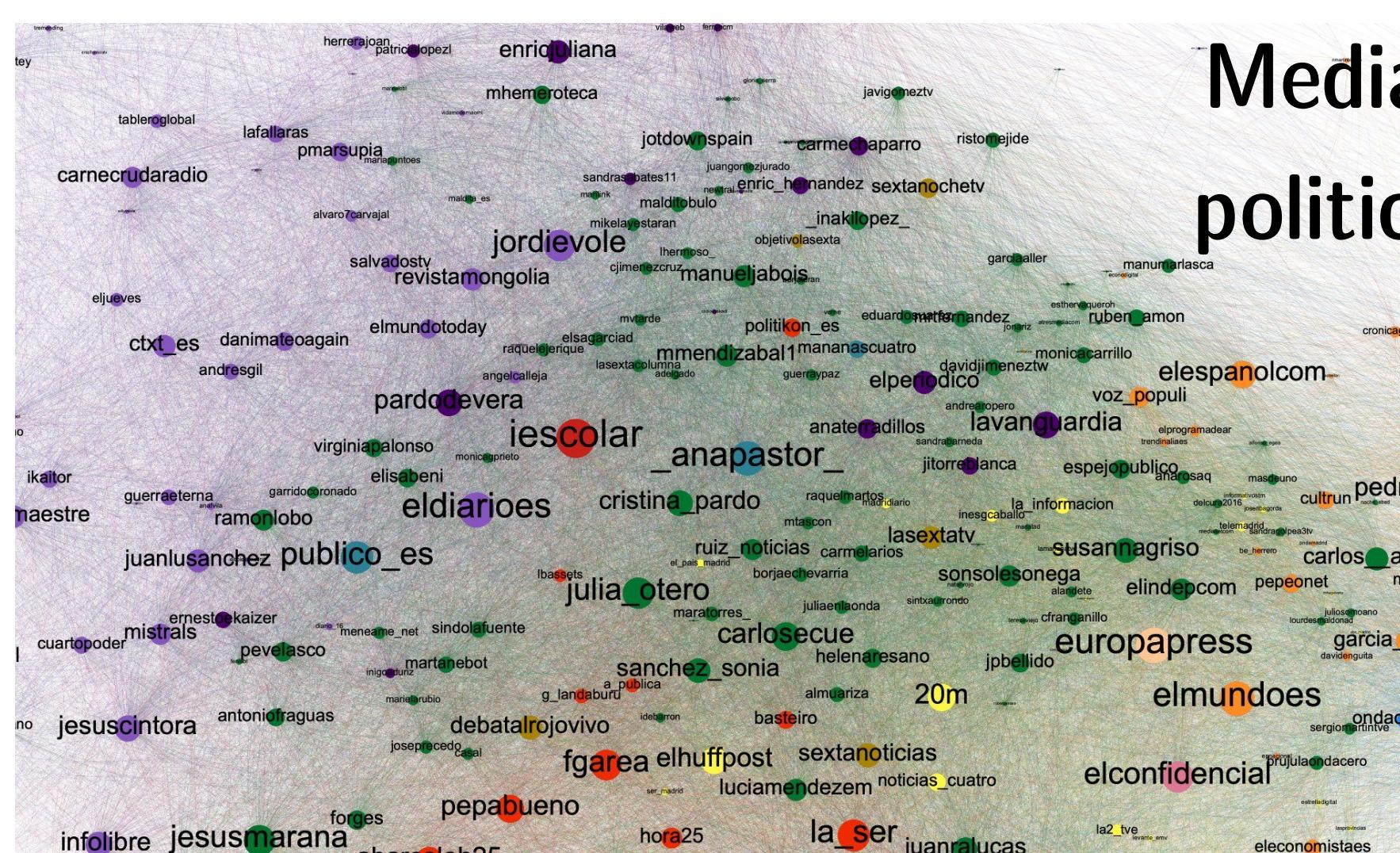
Flavors (cont.)



Star Wars



Media and politicians?

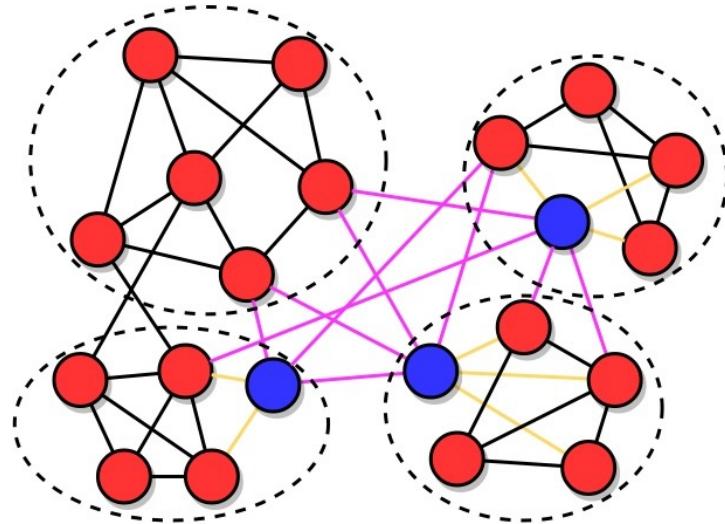


<https://twitter.com/jbo/status/1120444347772821504/photo/1>

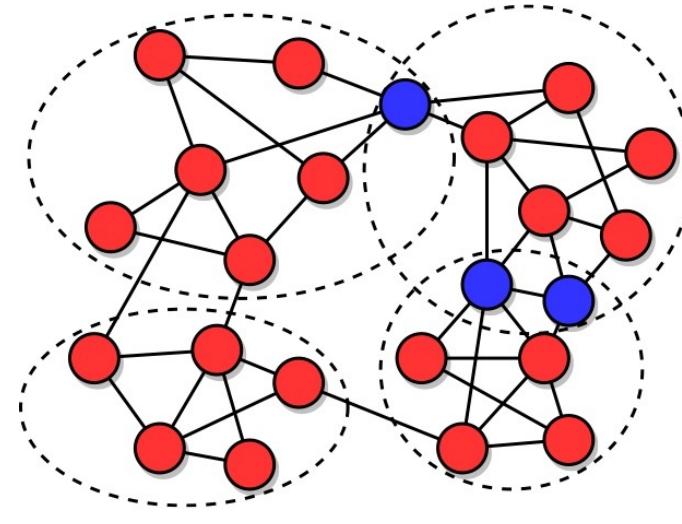
Partitions vs Overlapping communities

Hierarchical communities

Partition vs Overlapping communities



Partition, or *hard* clusters

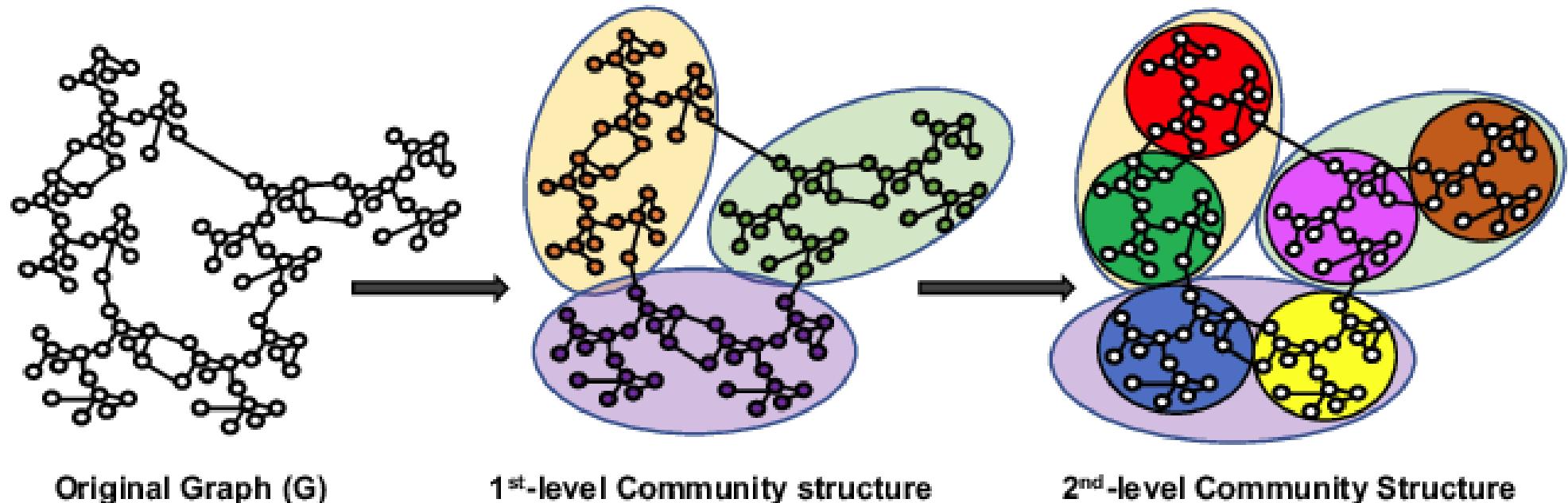


Overlapping communities, or *soft* clusters

What's special about blue nodes?

Blue nodes are in more than one community

Hierarchical communities



Original Graph (G)

1st-level Community structure

2nd-level Community Structure

Summary

Things to remember

- Many networks have community structure
- Sometimes it's:
 - One dense sub-graph
 - Two communities (polarization)
 - Multiple communities
- Partitions vs overlapping communities
- Hierarchical communities