



DCS/CSCI 2350: Social and Economic Networks

Intro to Graph Theory

Mohammad T. Irfan

www.mtirfan.com/DCS-2350



Networks:

A modern way of looking at,
reasoning about, and making
sense of the world

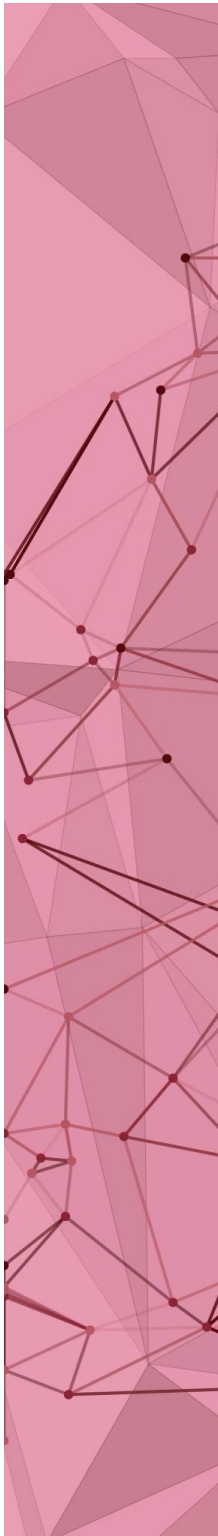
12 real-world examples

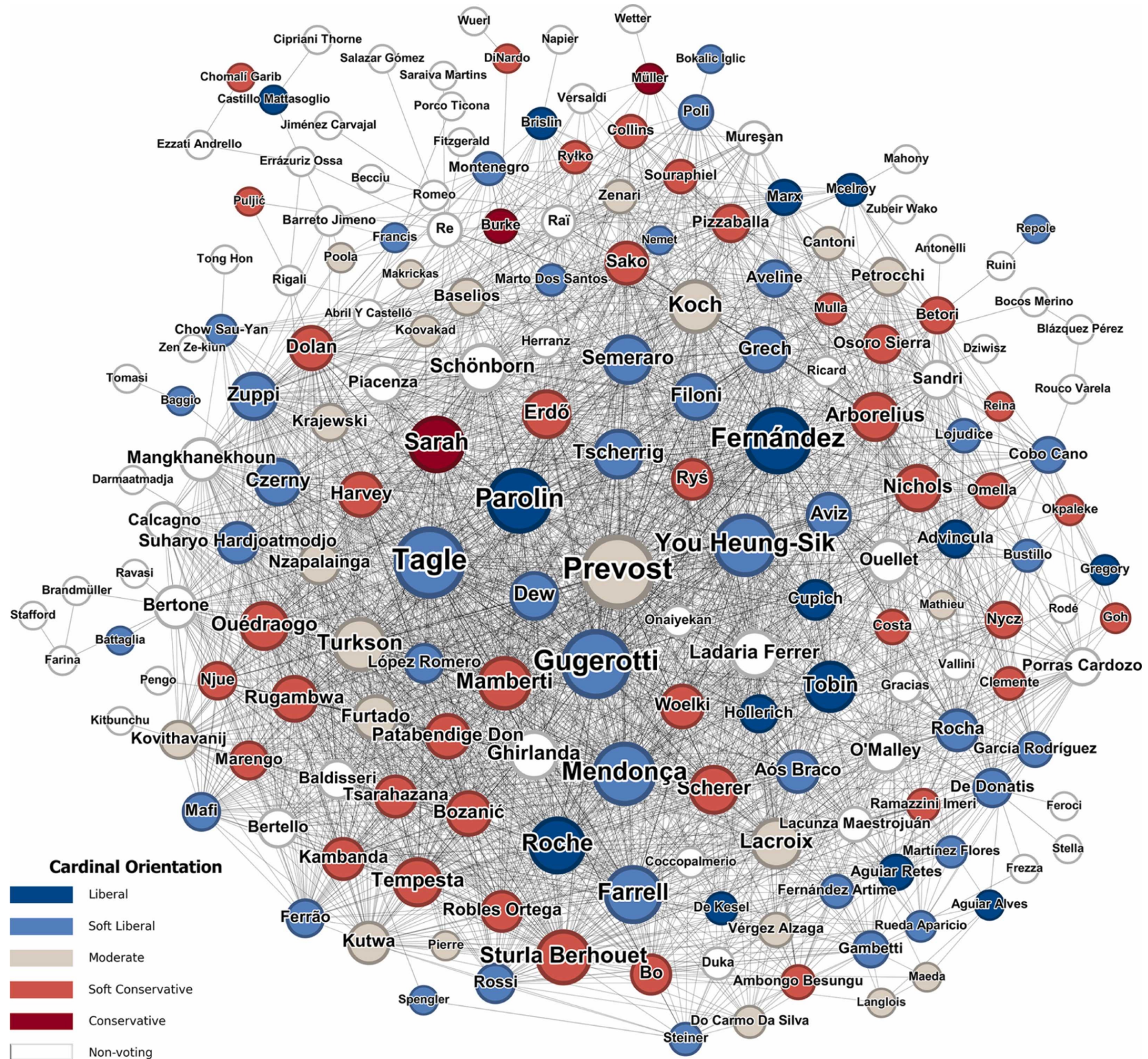
In the network of the conclave: Social connections and the making of a pope

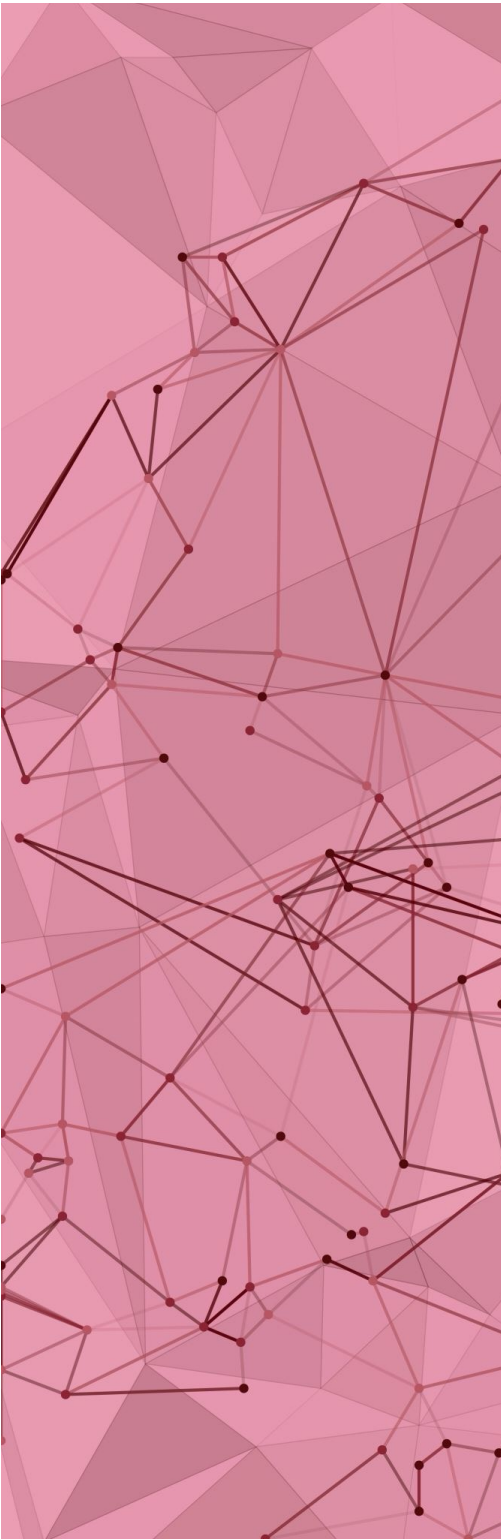
“Our descriptive study—publicly released prior to the May 8, 2025 election of Pope Leo XIV—shows that Cardinal Robert F. Prevost, largely ignored by pundits, bookmakers, and AI models, held a uniquely advantageous position in the Vatican network, by virtue of being central in multiple respects.”

Link to paper:

<https://www.sciencedirect.com/science/article/pii/S0378873325000449>

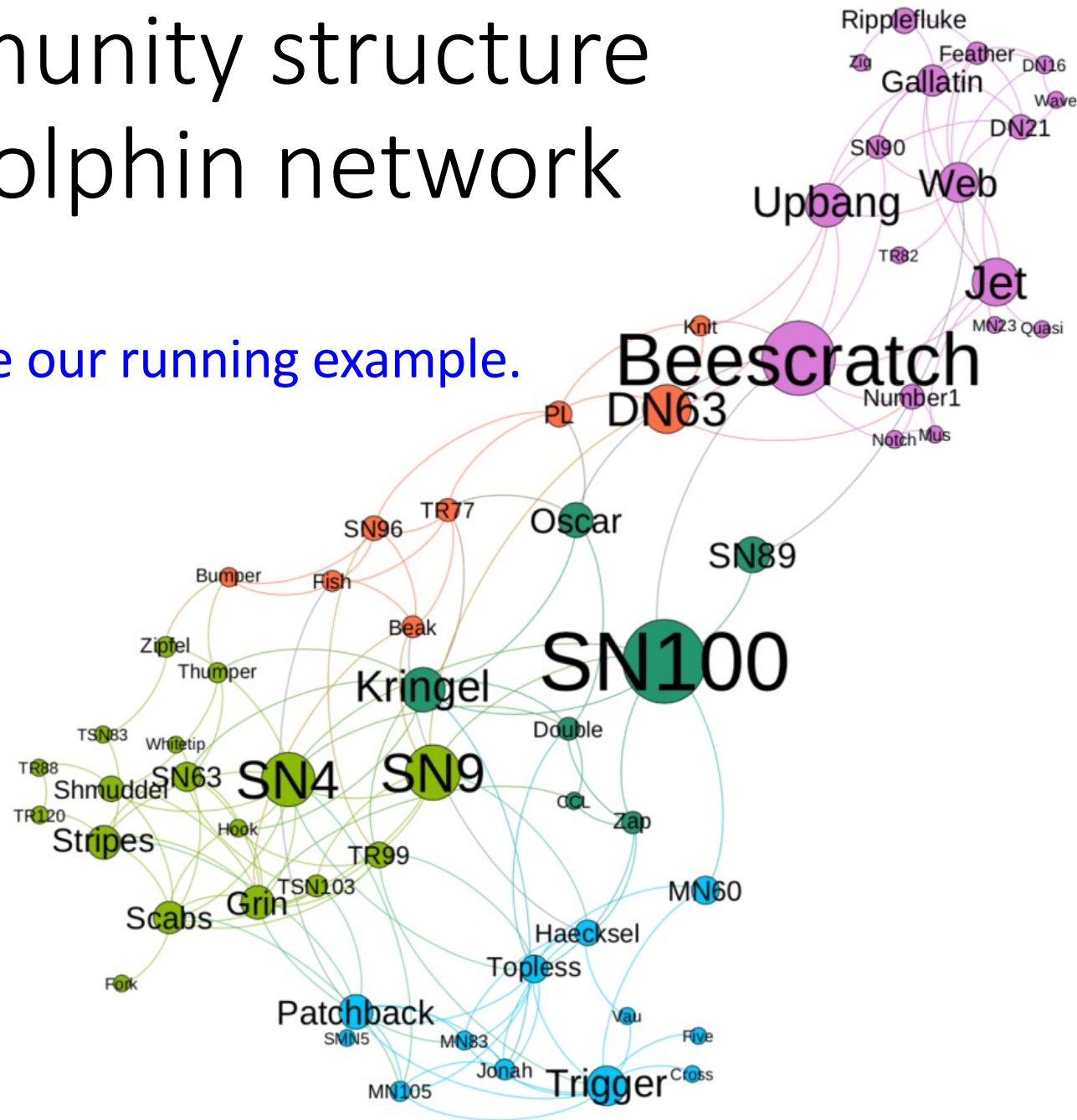






From the Pope to ...

This will be our running example.





Reading: Ch 2 (Easley-Kleinberg)

Also see handout

Networks/Graphs

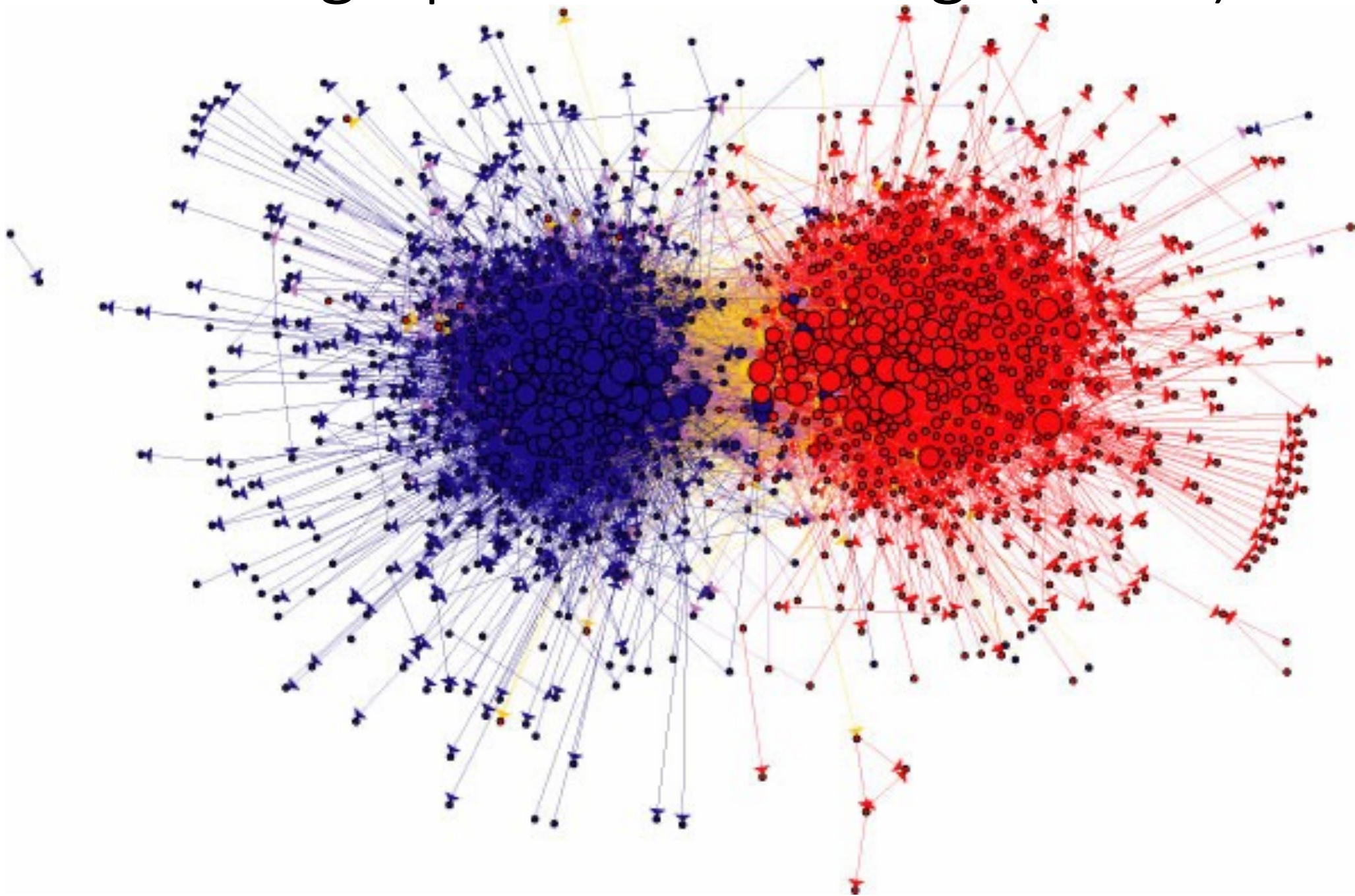
Basic Terminology

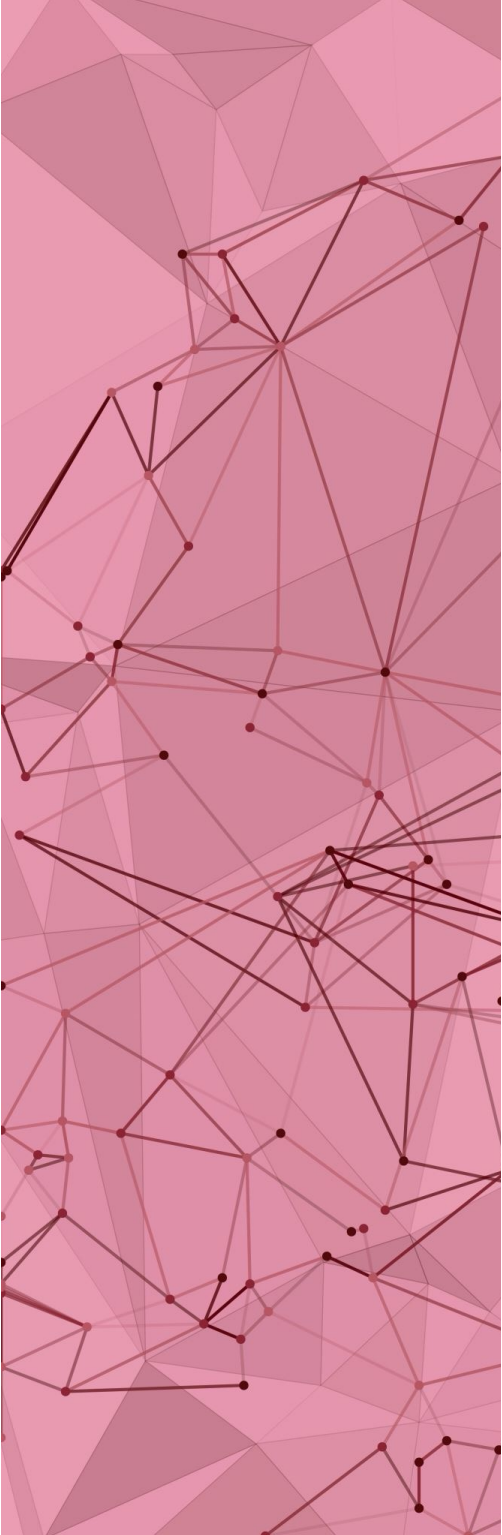
"Graph theory is a terminological jungle, in which any newcomer may plant a tree." – John Barnes

Undirected graph: Where do friends live? (2010)



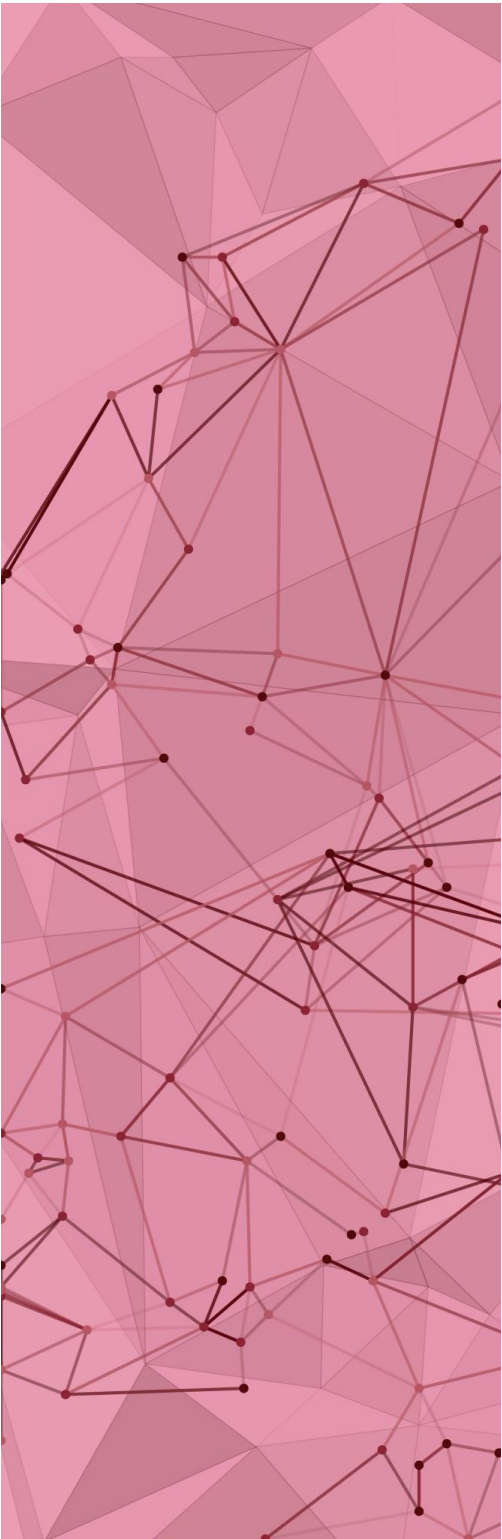
Directed graph: Political blogs (2005)





Some ~~Properties~~ Puzzles

Degree-sum formula
Max # of edges

The background of the slide is a vertical rectangle. The left half of this rectangle is filled with a complex, abstract pattern. It features a network graph with numerous small, dark red circular nodes connected by thin, dark red lines. This graph is overlaid on a low-poly mesh of various shades of pink and magenta, creating a layered, geometric effect. The right half of the rectangle is a solid, light pink color.

Paths and Cycles

For studying the flow of something in a network

Search for:

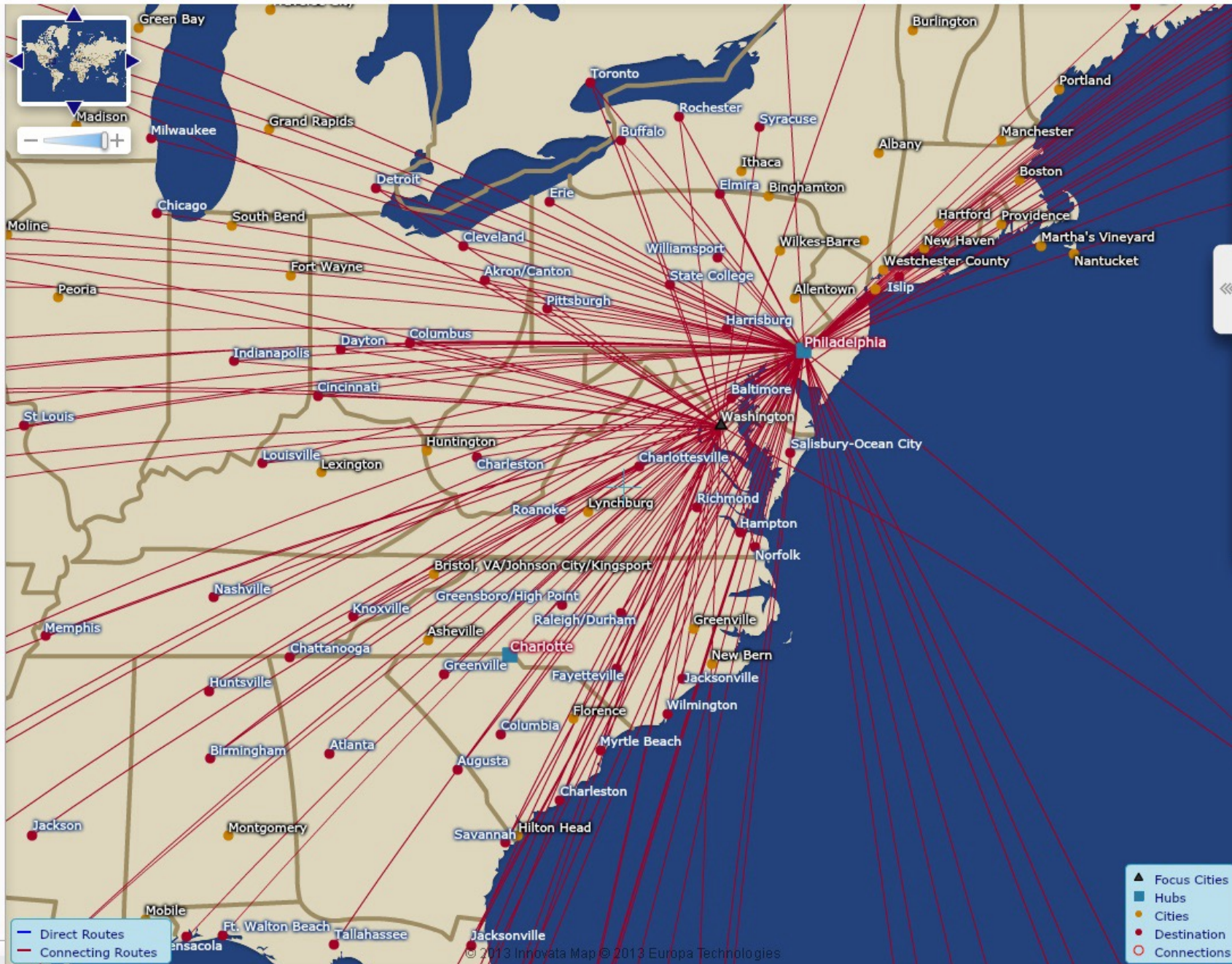
Destinations

Leaving from:

Islip (US)

- ☒ Include connections
☒ Non-stop flights only
☐ Include codeshares

Search >

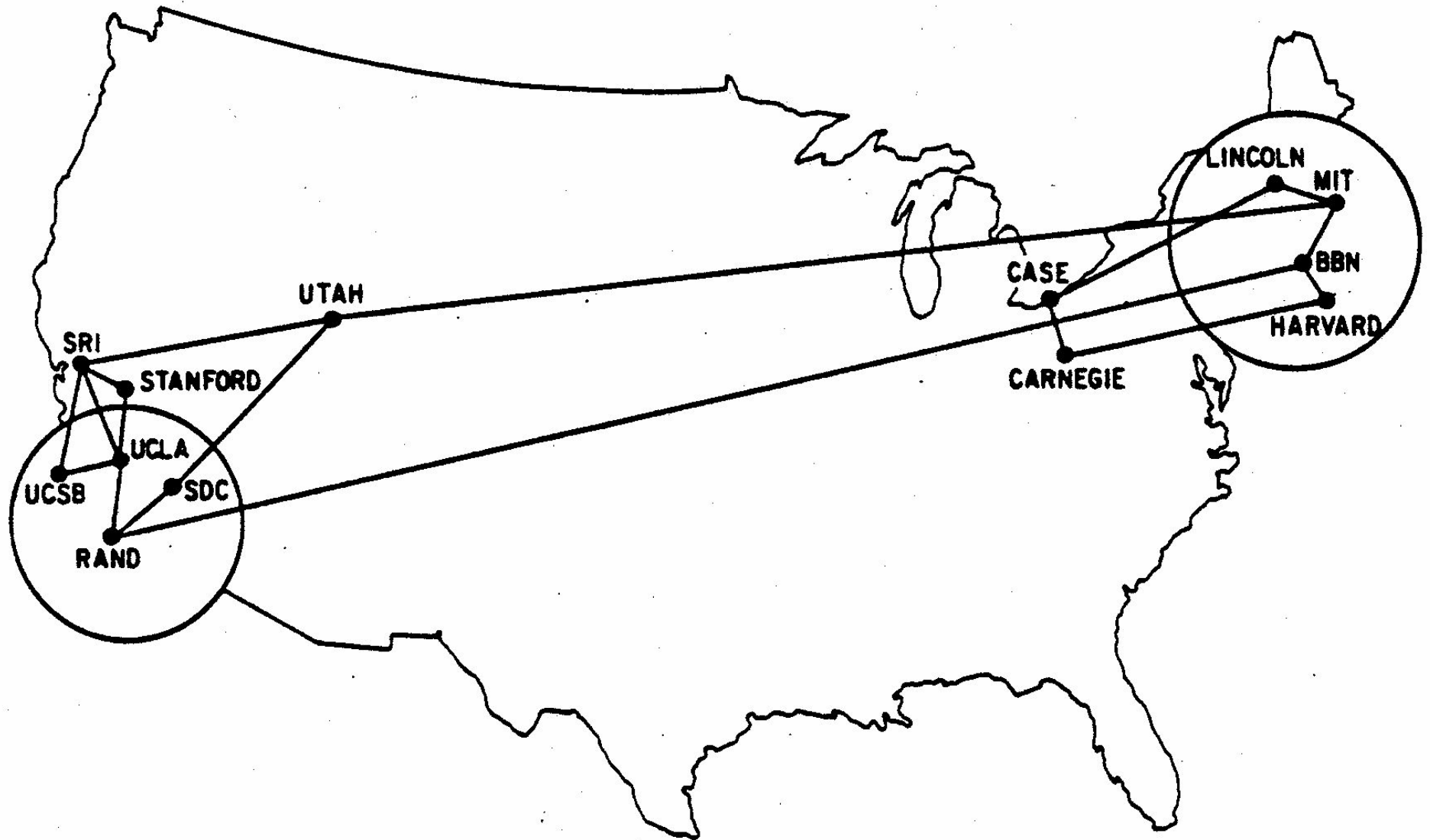




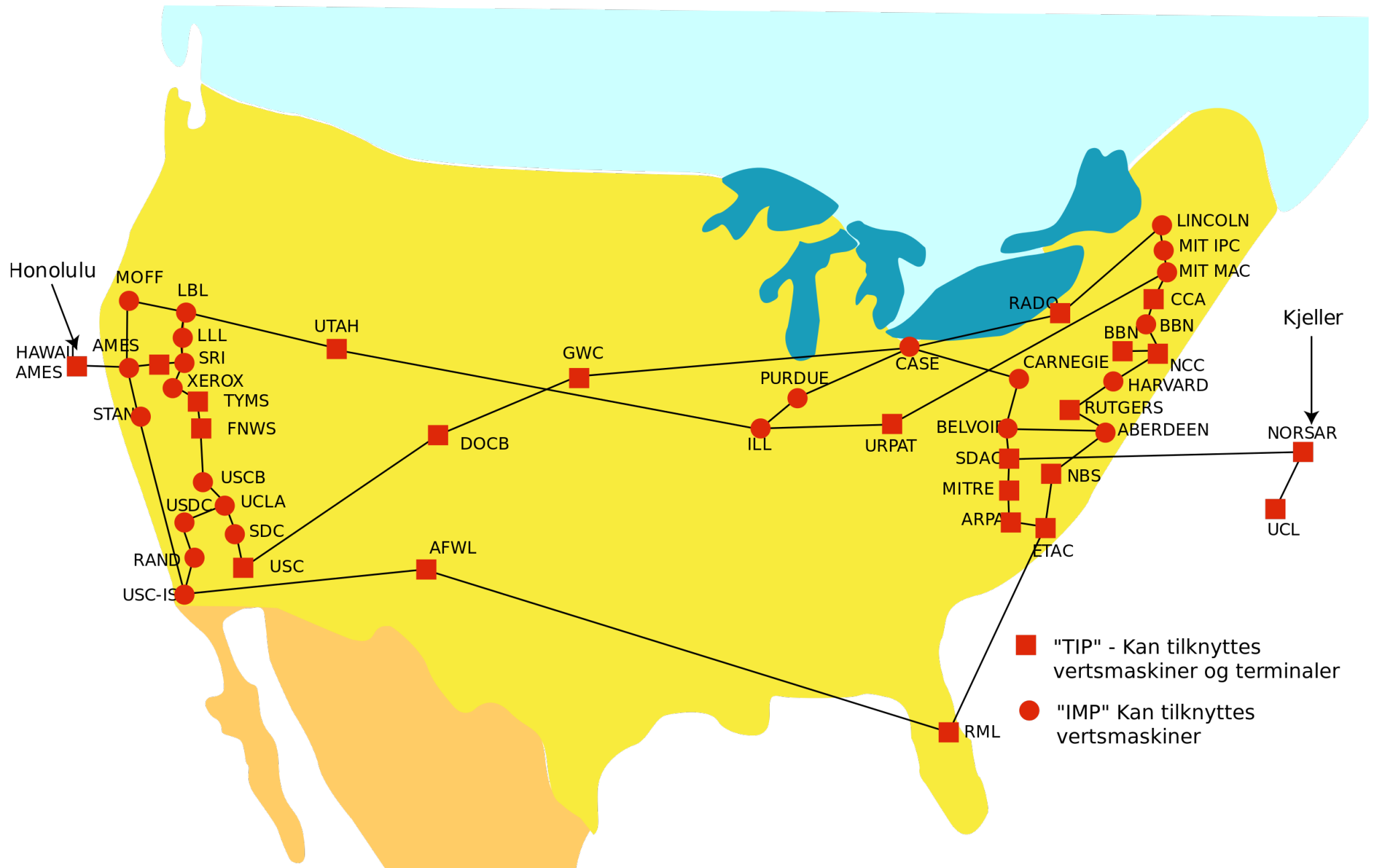
1968

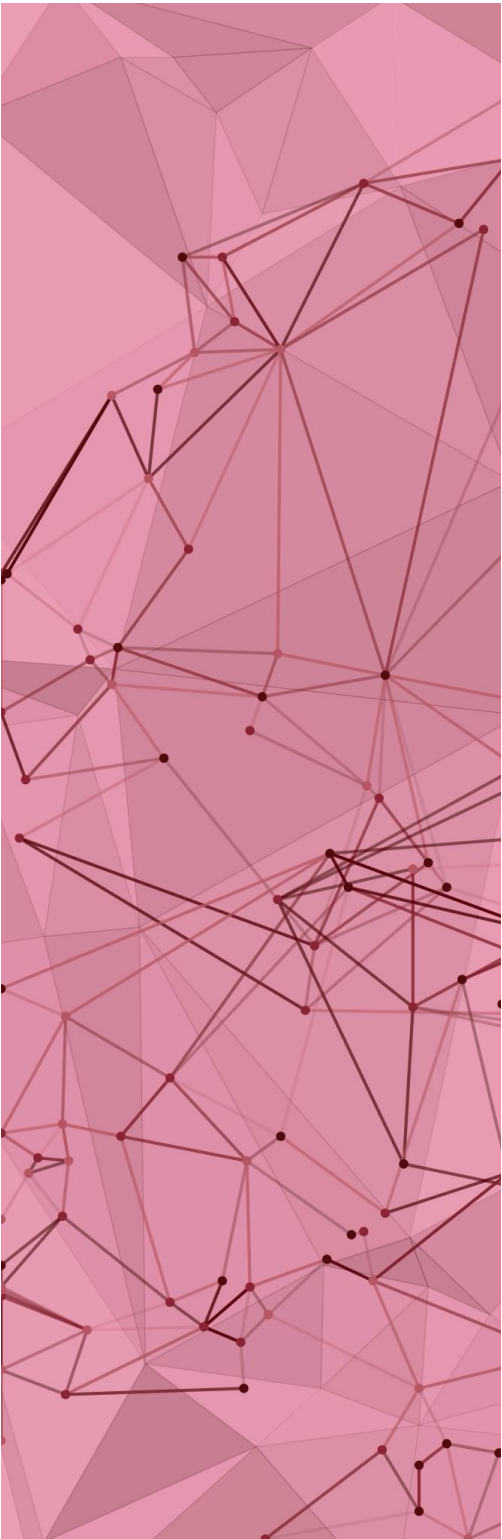
American Airlines
System map

ARPANET (1970)



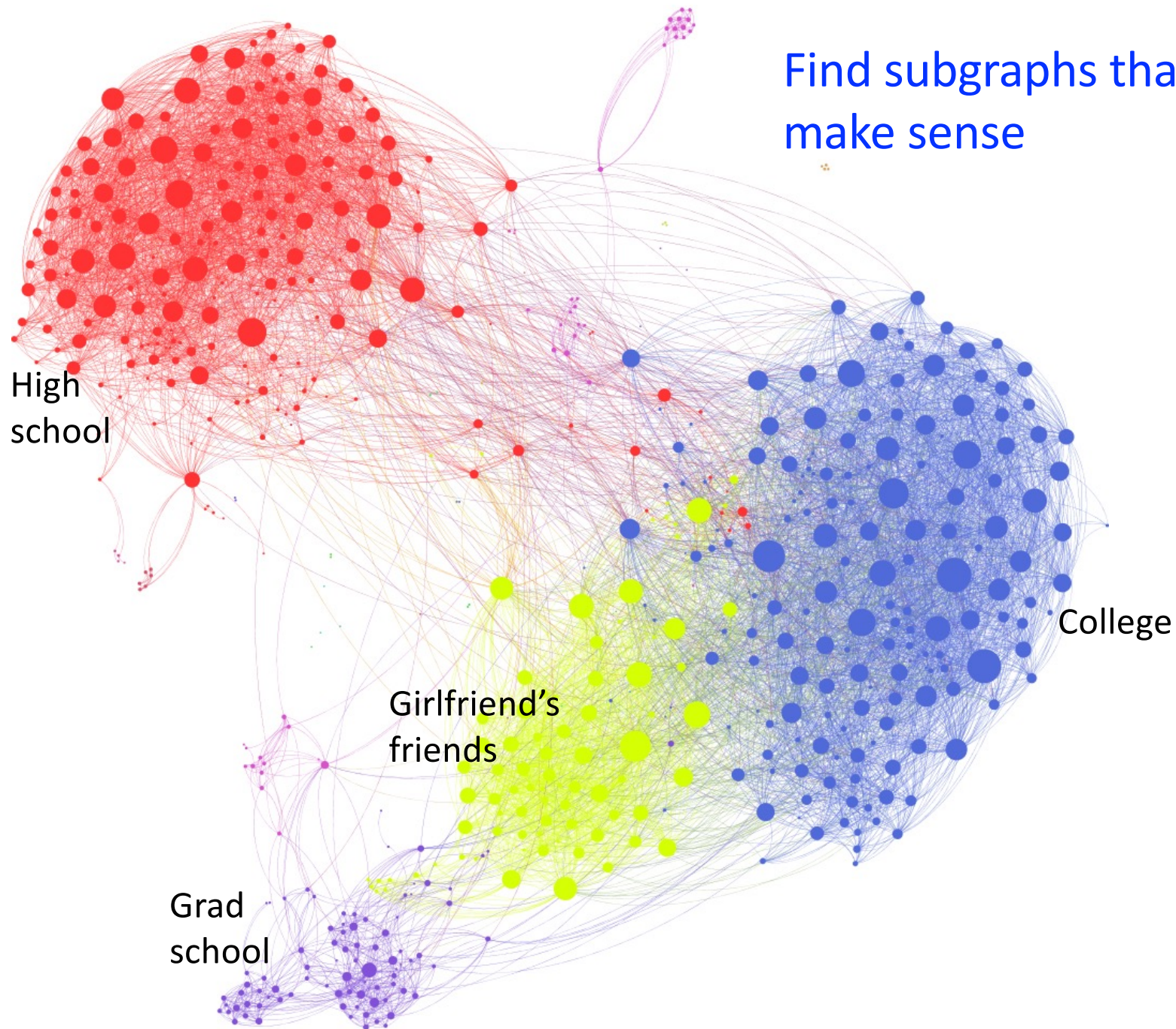
ARPANET (1974)



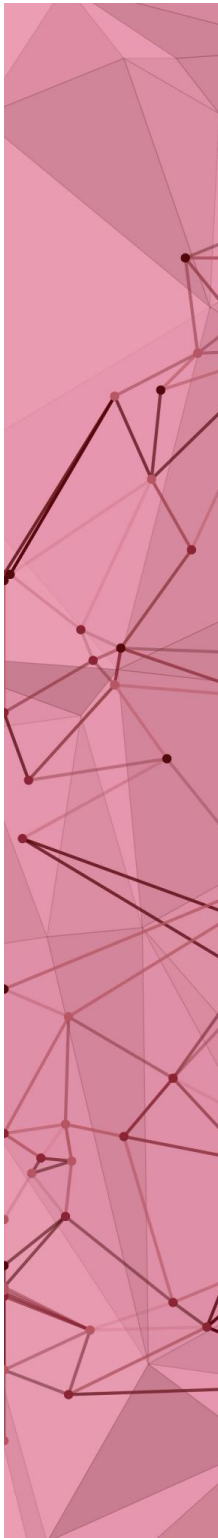


Connectivity:
subgraph
component

Find subgraphs that
make sense

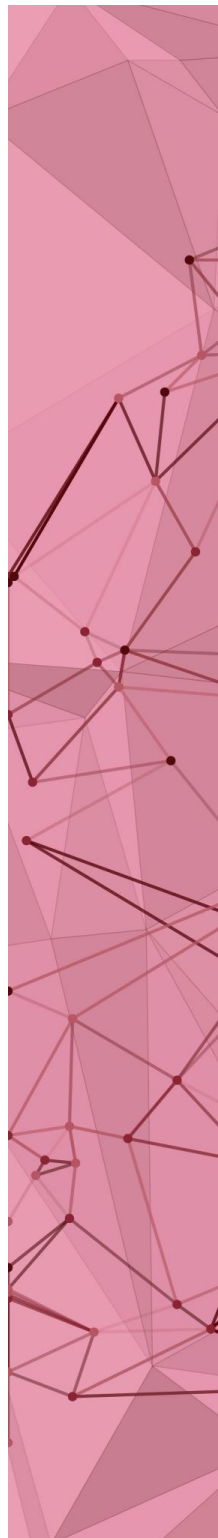
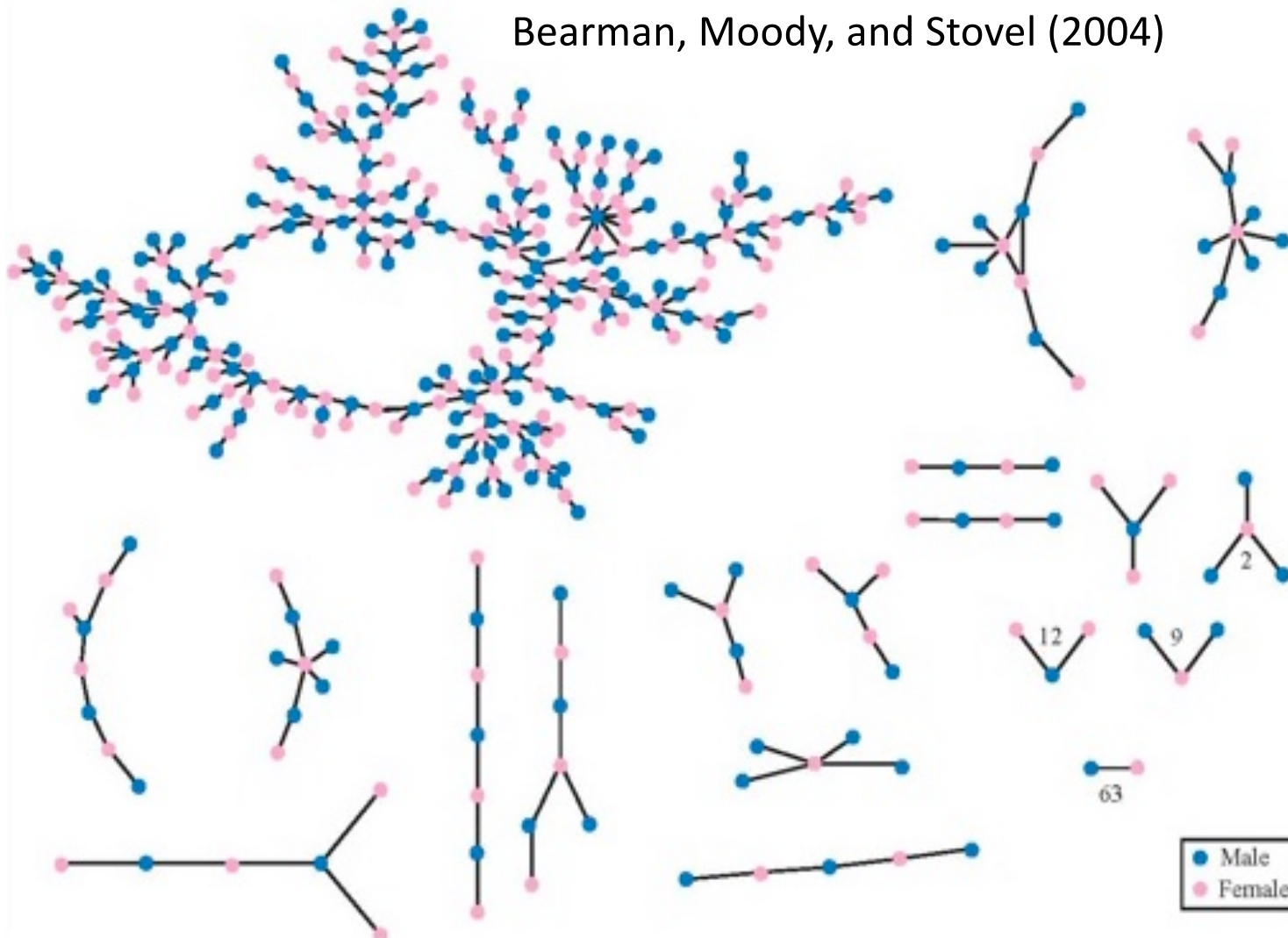


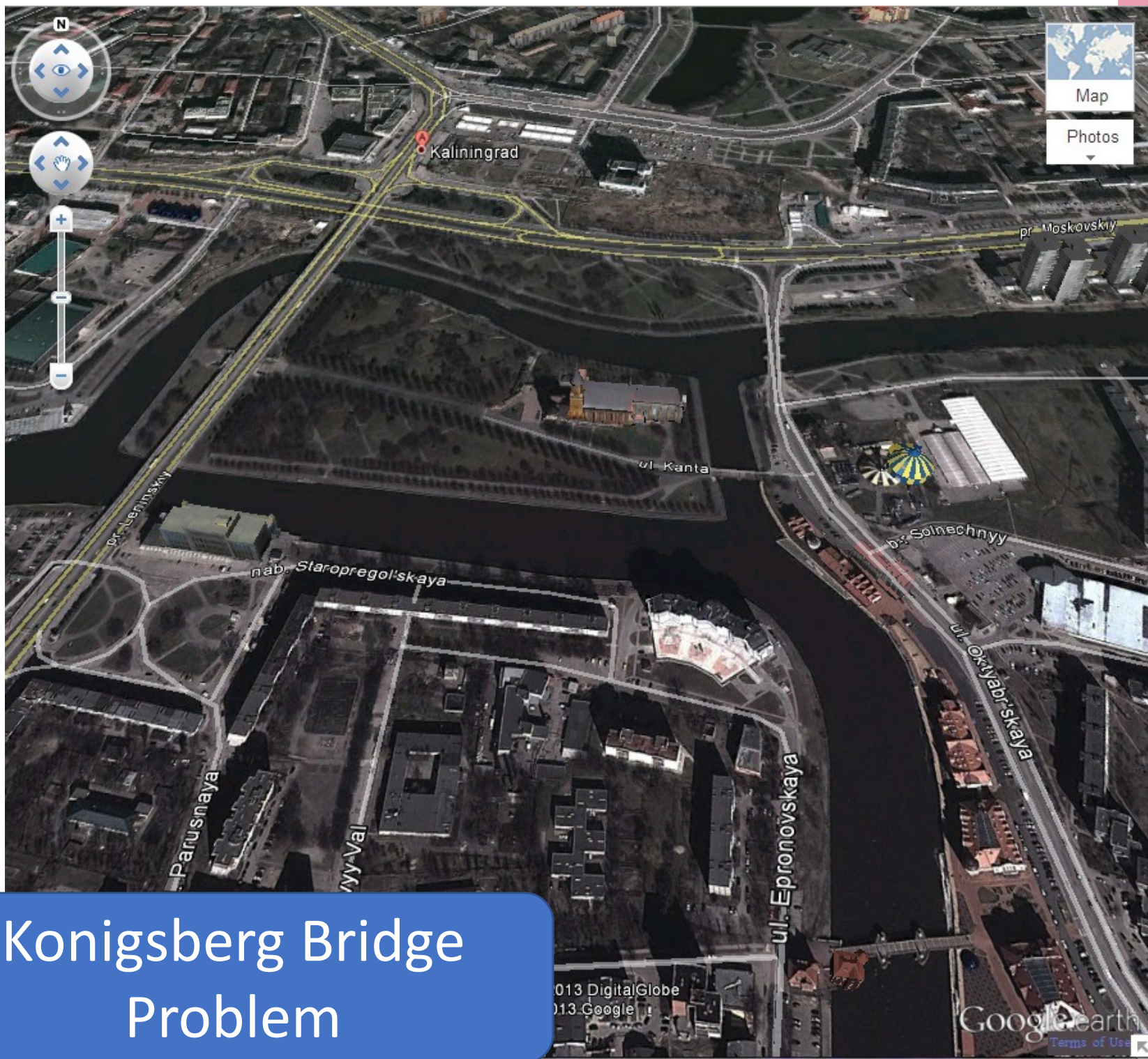
<https://griffgraphs.wordpress.com/2012/07/02/a-facebook-network/>



High school relationships (1993-95)

Bearman, Moody, and Stovel (2004)





Königsberg Bridge Problem

Review of vocabulary

Network $\leftrightarrow$ Graph

Node $\leftrightarrow$ Vertex

Edge: undirected vs. directed (arc)

Degree of a node

Endpoints of an edge

Directed, undirected, mixed graphs

Simple vs non-simple graph

Degree-sum formula

Maximum number of edges

Path

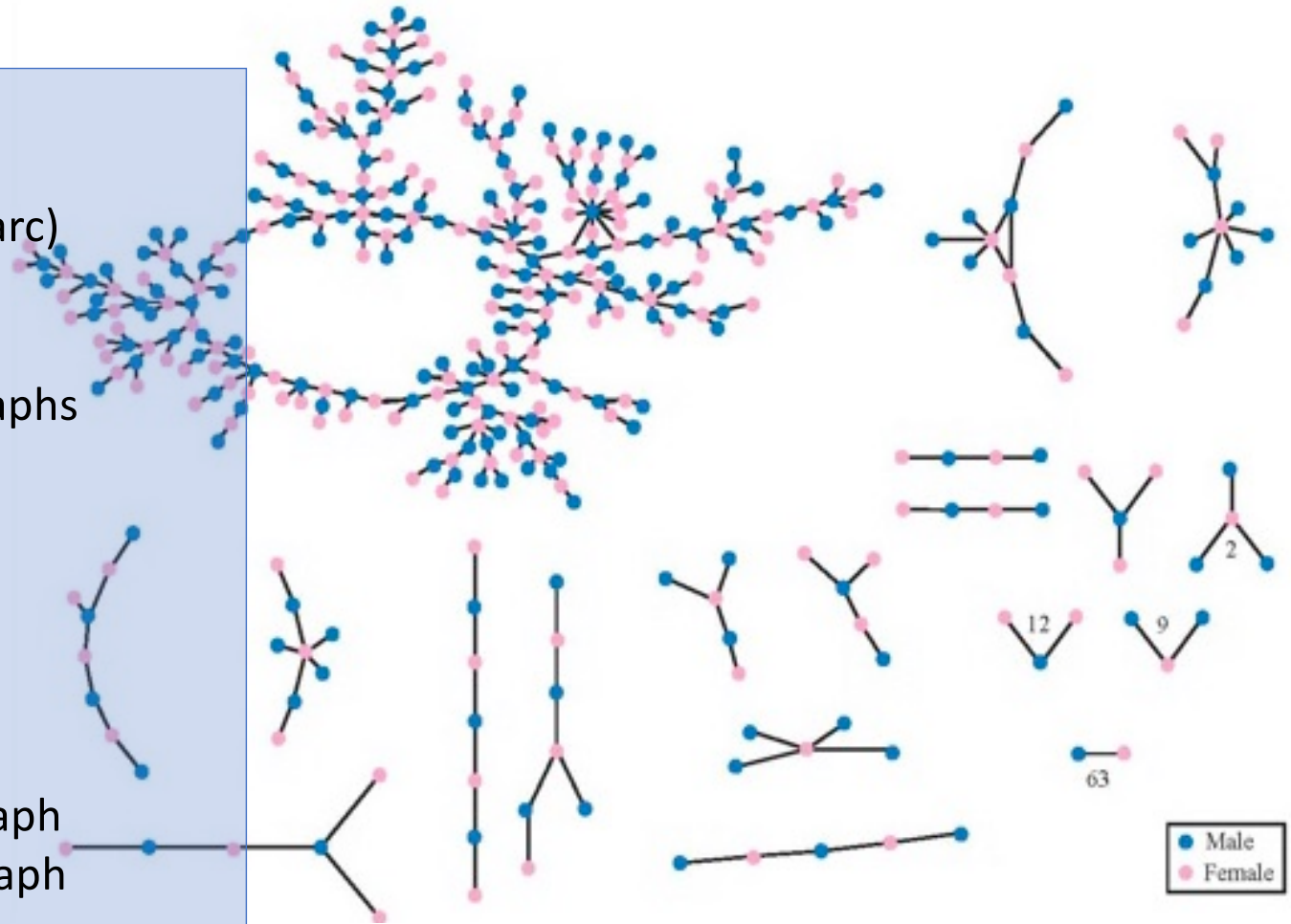
Cycle

Subgraph

Connected vs. disconnected graph

Connected components of a graph

Eulerian circuit problem



High school relationships (1993-95)

Reading

Chapter 2 of Easley-Kleinberg



Homework

- Submit FA 1 on Canvas
- Complete AI Ethics module to access AI tools:

<https://librechat.bowdoin.edu>

