# Introduction to Network Science

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Network Science: Motivation

- What we can get by modeling the world around us as a network?
  - For example, model the connectivity among your Facebook contacts
    - Understand information diffusion
    - Visualize connections between people (using automated tools)
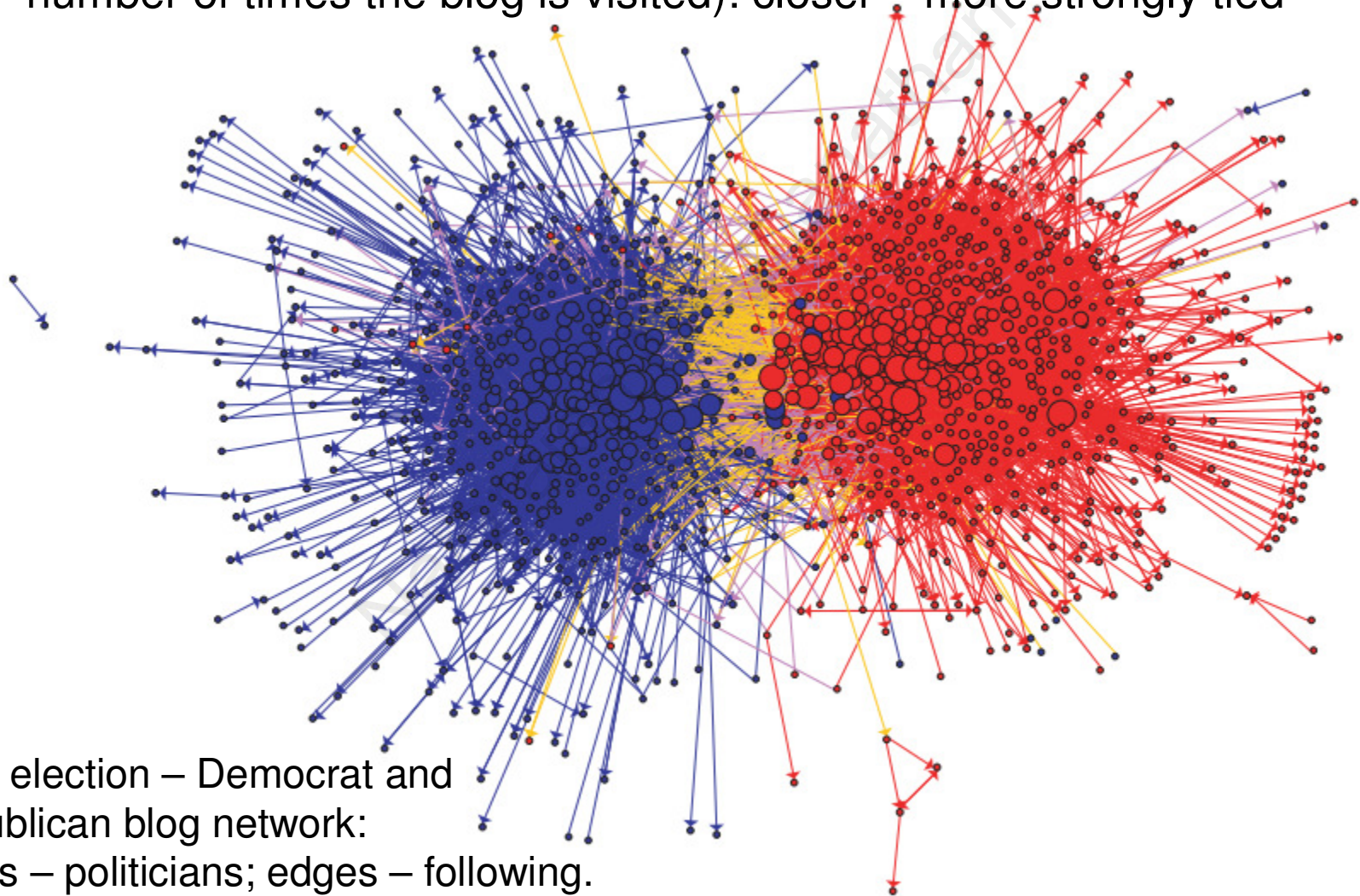   - Elegant way to connect disparate information (people, associations)
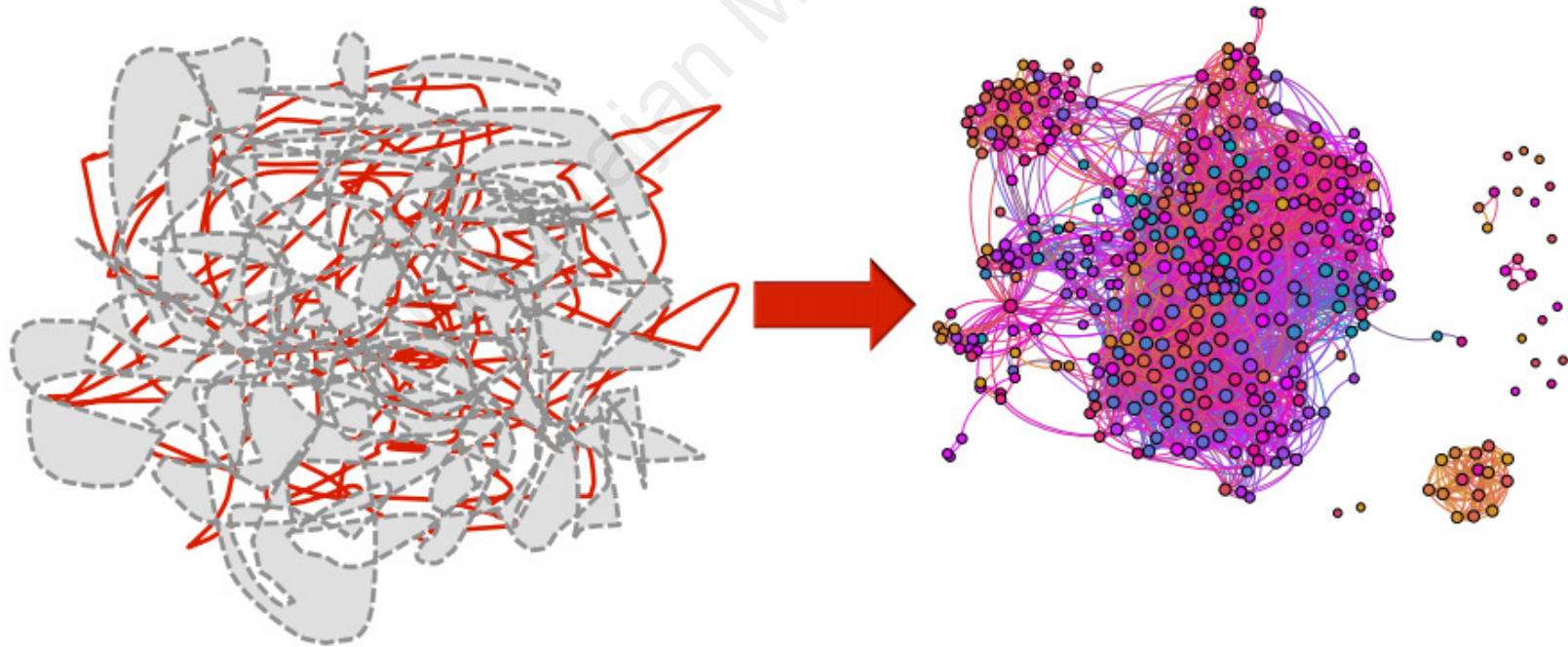
Structure of the Internet: At the Level of Autonomous Systems

Source: http://www-personal.umich.edu/~mejn/netdata/

Political Blogs

- Blog Network of who follows who.
- The length of the edges shows the closeness (inversely related to number of times the blog is visited): closer – more strongly tied

2012 election – Democrat and
Republican blog network:
nodes – politicians; edges – following.

E-mail Communication Network

- Black edges – hierarchy in an organization (who reports to whom)
- Gray edges – Two people are connected if they have at least exchanged two emails in a certain time period.
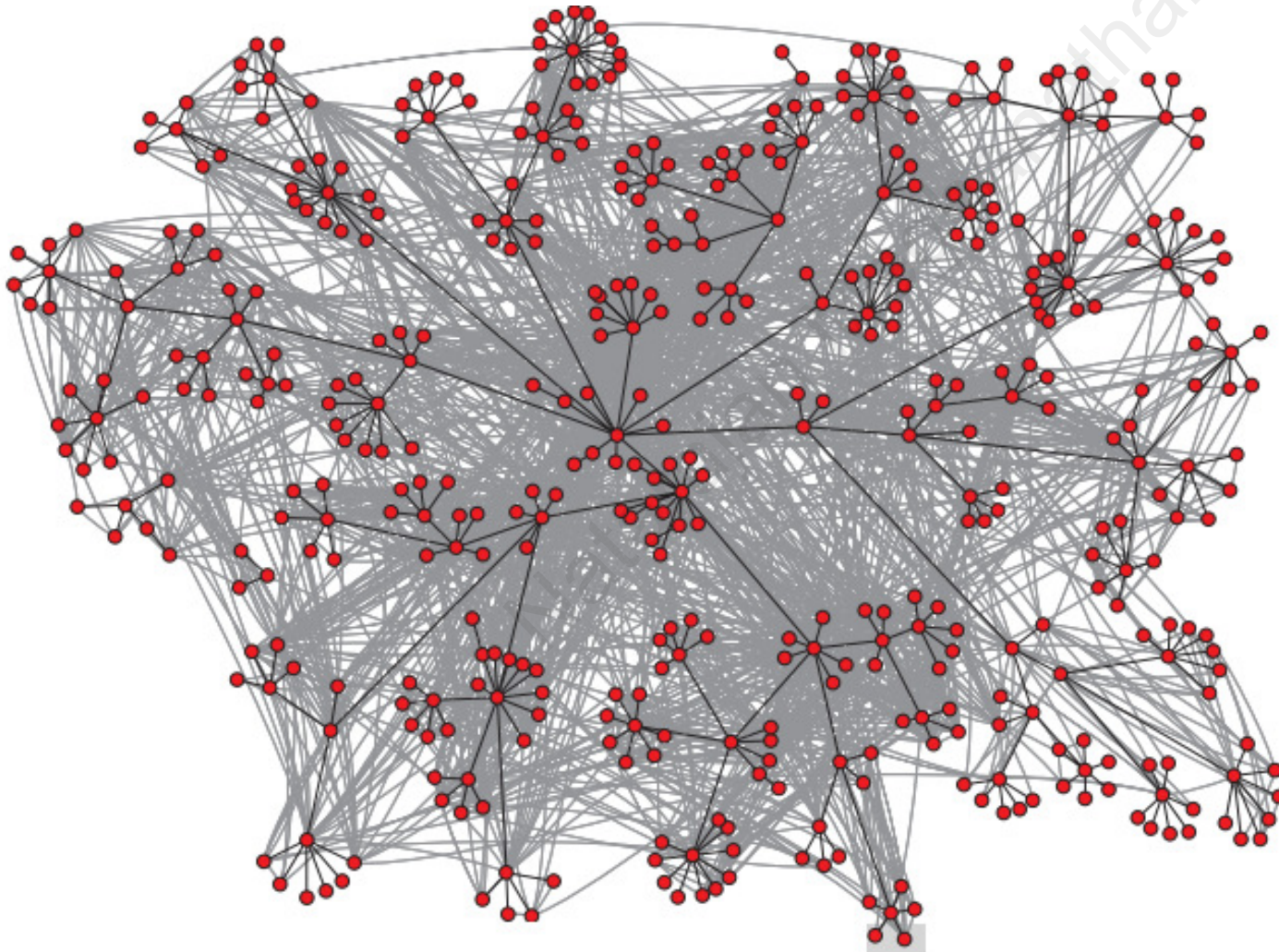
E-mail communication is more likely among individuals who are more likely together.

There are also enough shortcuts that any two individuals are connected in a shorter path (getting the job done informally).
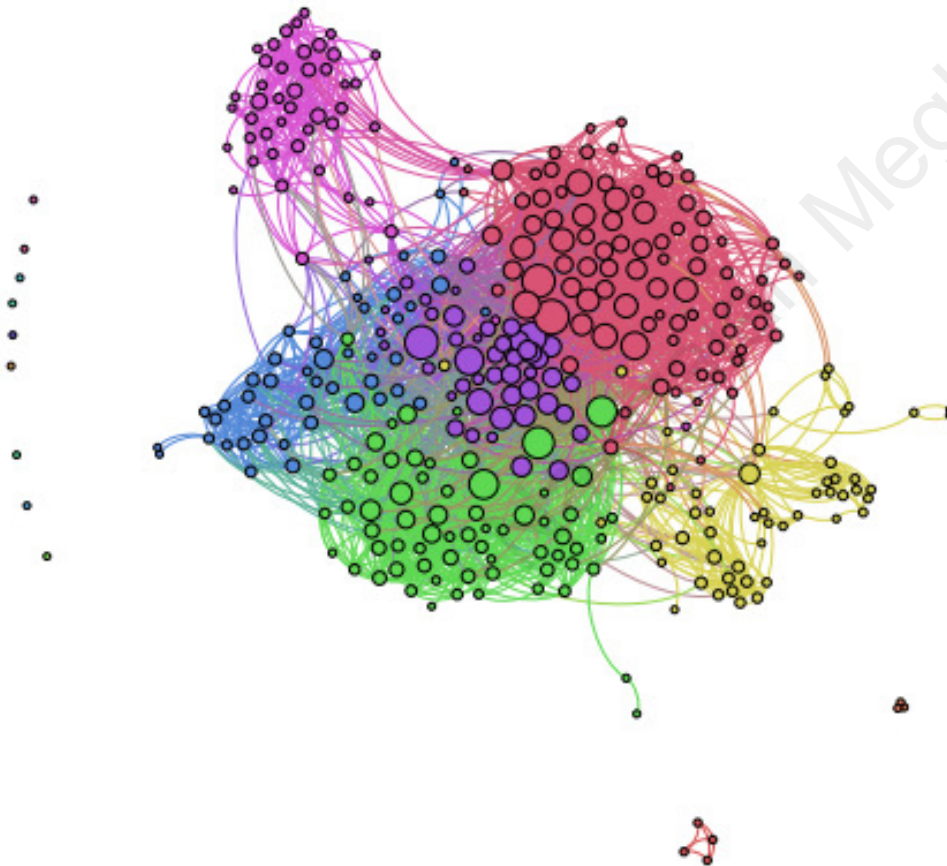
Facebook Network

- We can detect communities among a person's friends in Facebook – Using Community Detection algorithms

Communities based on workplace, school, college, etc.

People in a community are more closely connected.

What we will learn in this course?

- 1) Understanding the structure of networks
  – Connectivity of the nodes, how far apart are the nodes?
  – Whether some nodes are more important than others due to their position in the network?
  – Whether there are communities?

- 2) What models can mimic these network structures?
  – Randomly generated network
  – Preferential attachment (rich get richer - edges are more likely to be added to nodes that already have more edges)
  – Small world network - any two people on a Facebook graph are connected on average of 4.7 hops.
  – Optimization of network connections for customer satisfaction (airline network)

What we will learn in this course?

- 3) How network structure affects processes?
  - Information diffusion through a network (for good)
  - Diffusion of a virus? How (What immunization strategies to use) to prevent the spread
  - Opinion formation - consensus reached across the network as individuals continuously update their beliefs or opinion influenced by someone else' opinion?
  - How to accomplish task through coordination?
  - Resilience - if some nodes are removed, can the network still function?
    - Resiliency of infrastructure networks (road/rail networks, electricity grid) to random or intentional failures.