Social and Technological Networks

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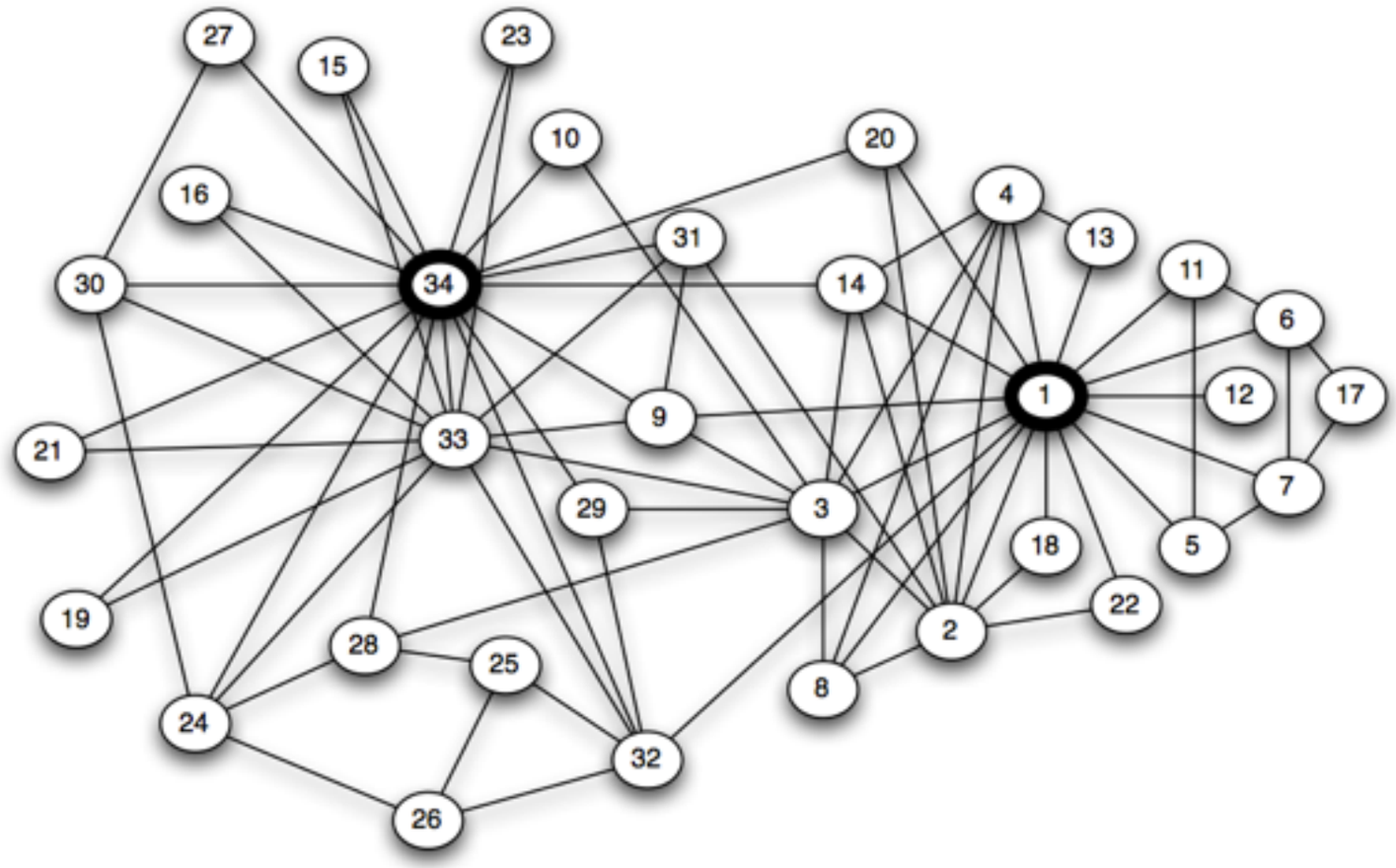
Social Networks

- Network of friends
- Node: Person
- Edge: Friendship
- Edge ab implies that a and b are friends



- E.g. Karate club network

Definition of networks

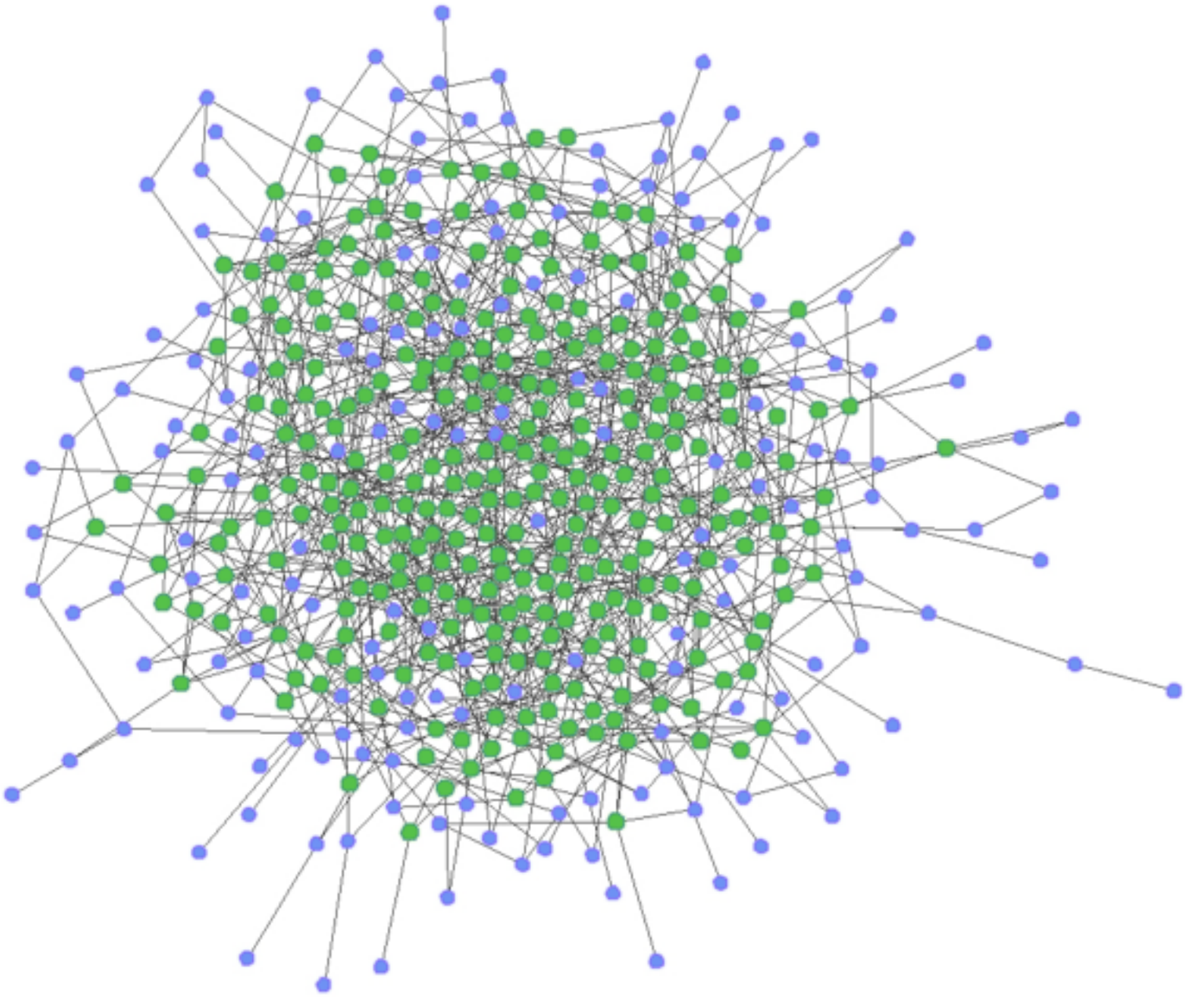
- A network or graph G = (V, E)
- V is a set of vertices
- E is a set of edges
- And edge e = (a,b), where a and b are vertices in V

Networks are informative

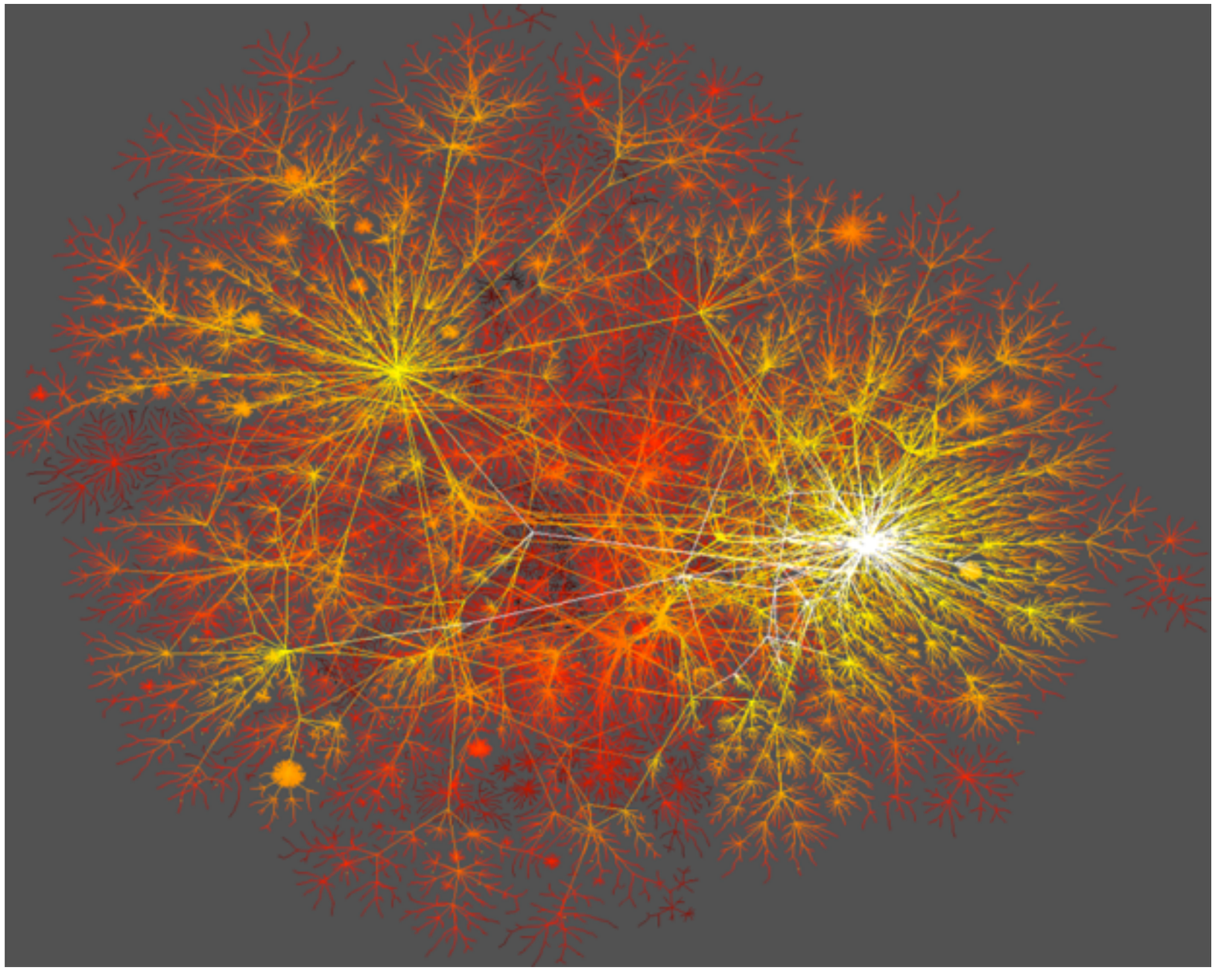
- It is possible to learn or predict things by understanding the network

Social interactions

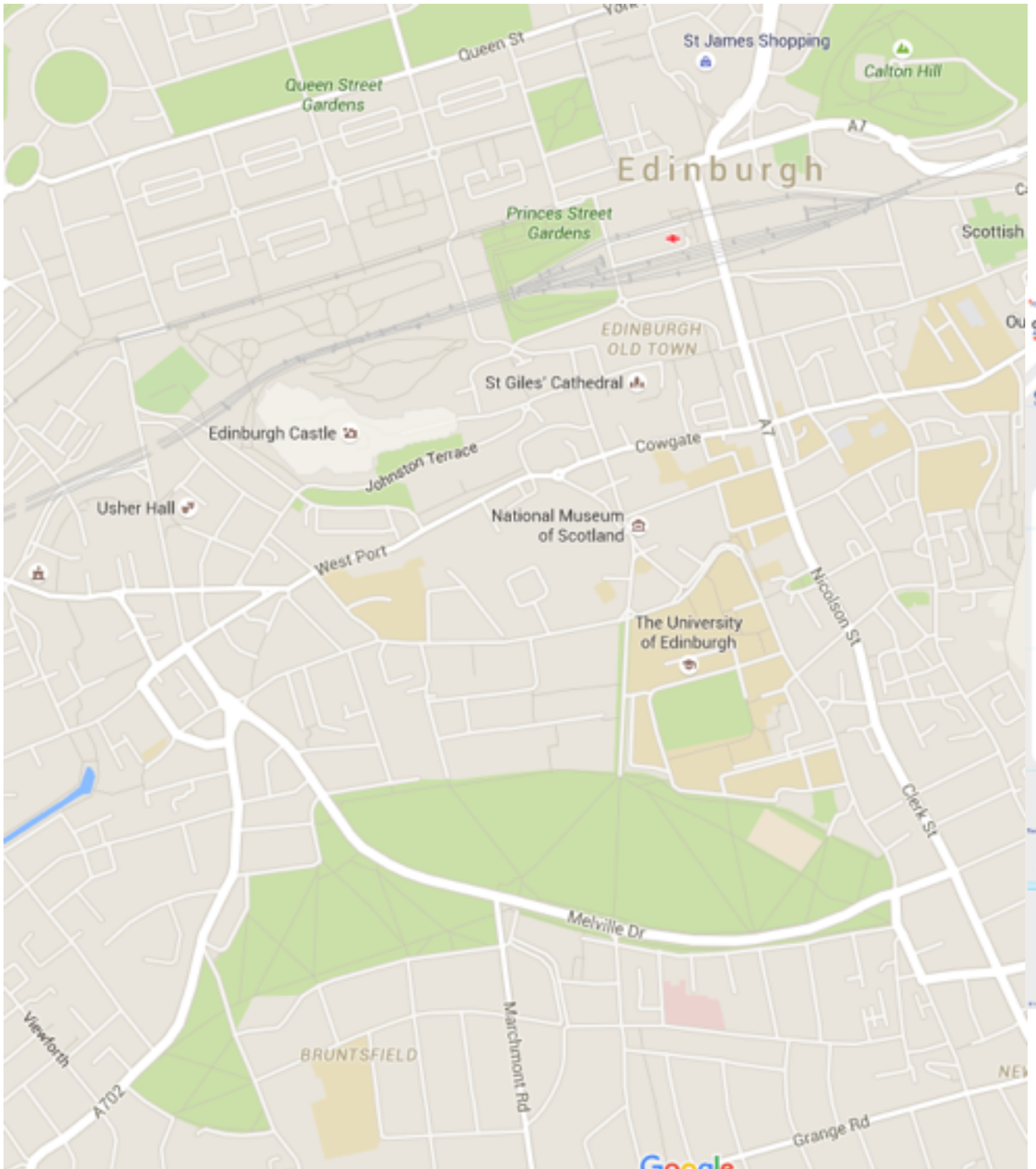
www



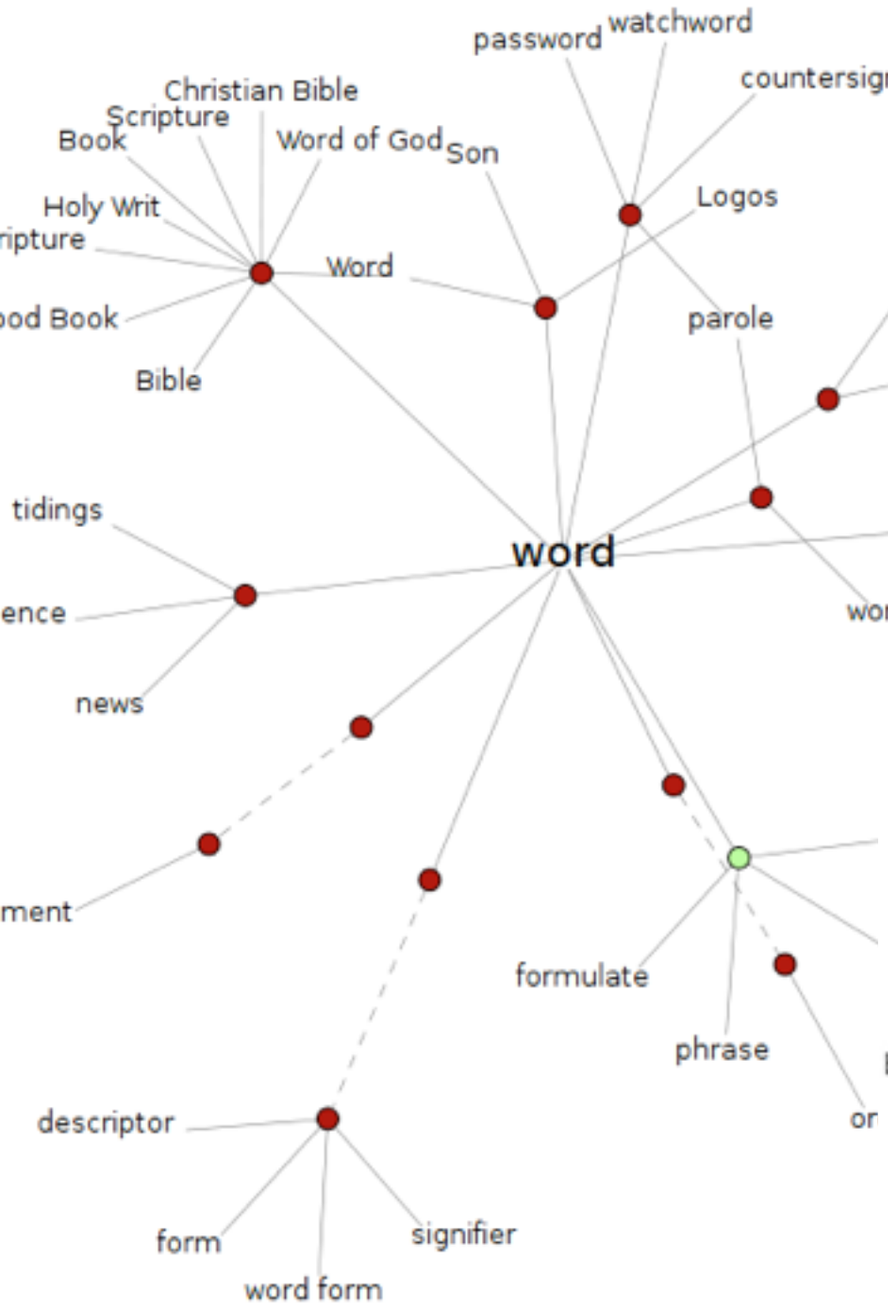
Computer networks: Internet



Roads and transport



Language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watchword
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Christian Bible
Scripture
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Son
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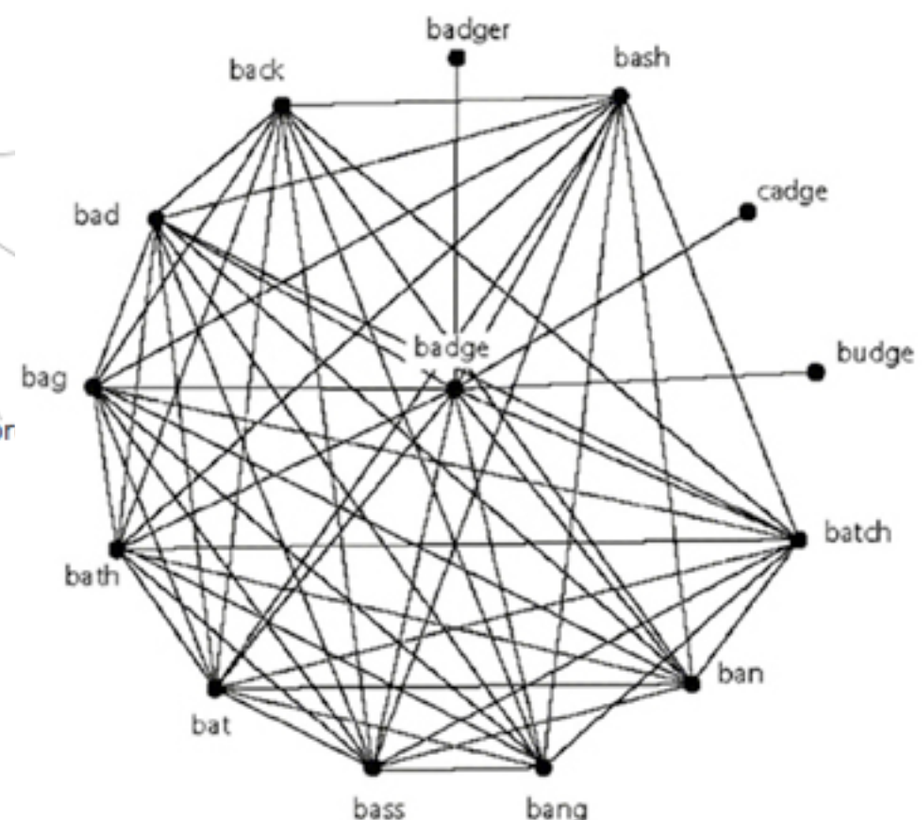
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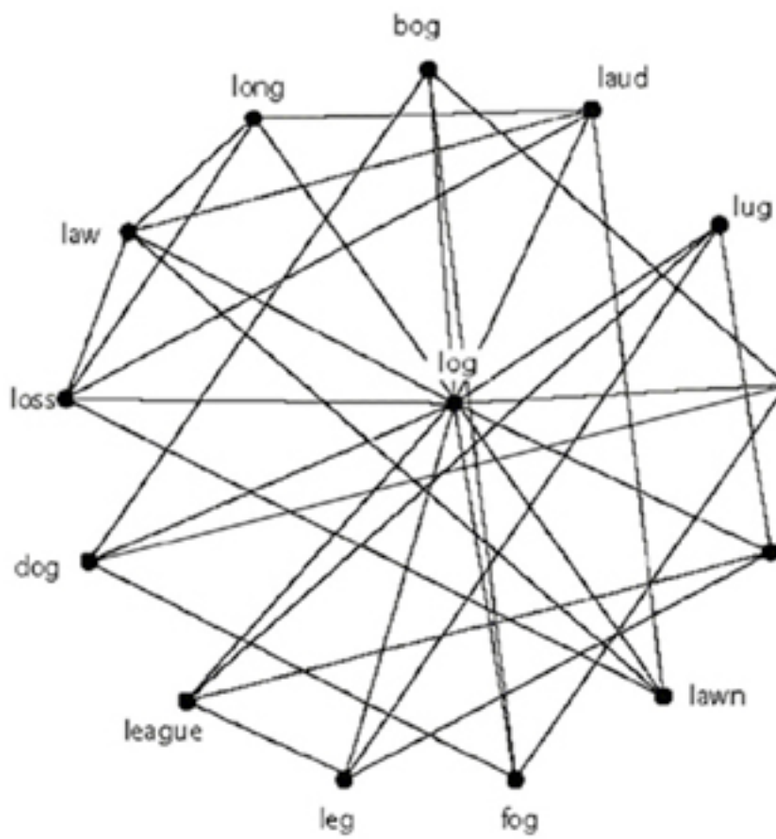
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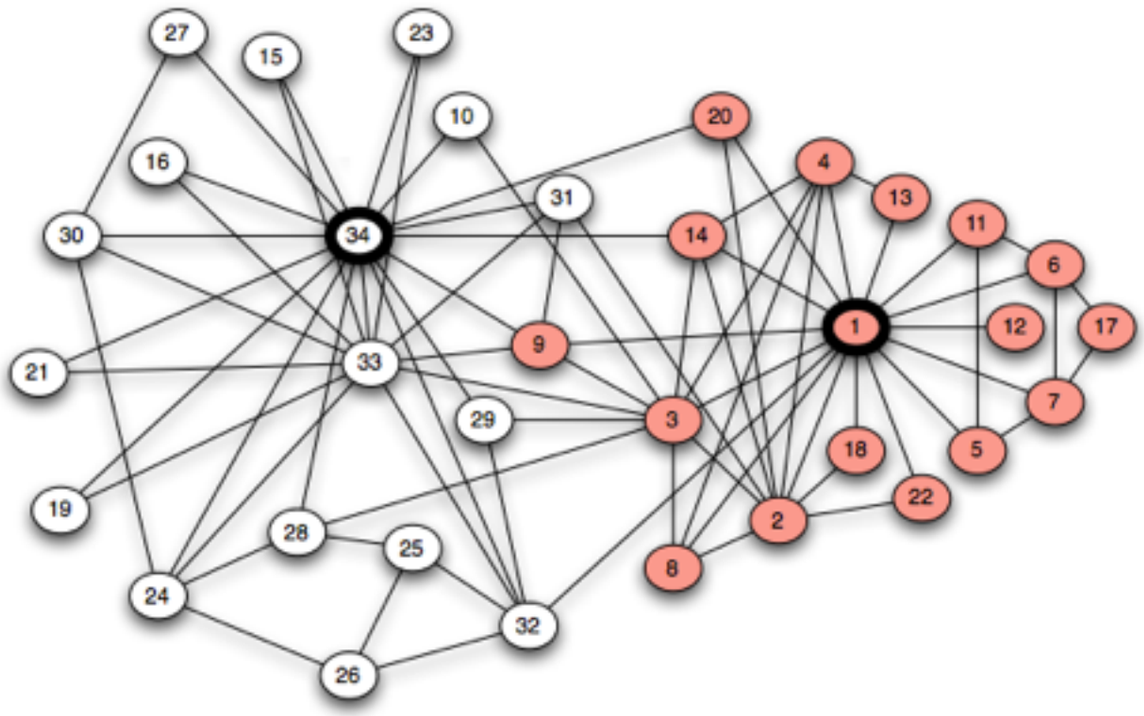
Chemistry/biology: Interaction between chemicals

Networks everywhere

- To understand the systems we need to understand the networks

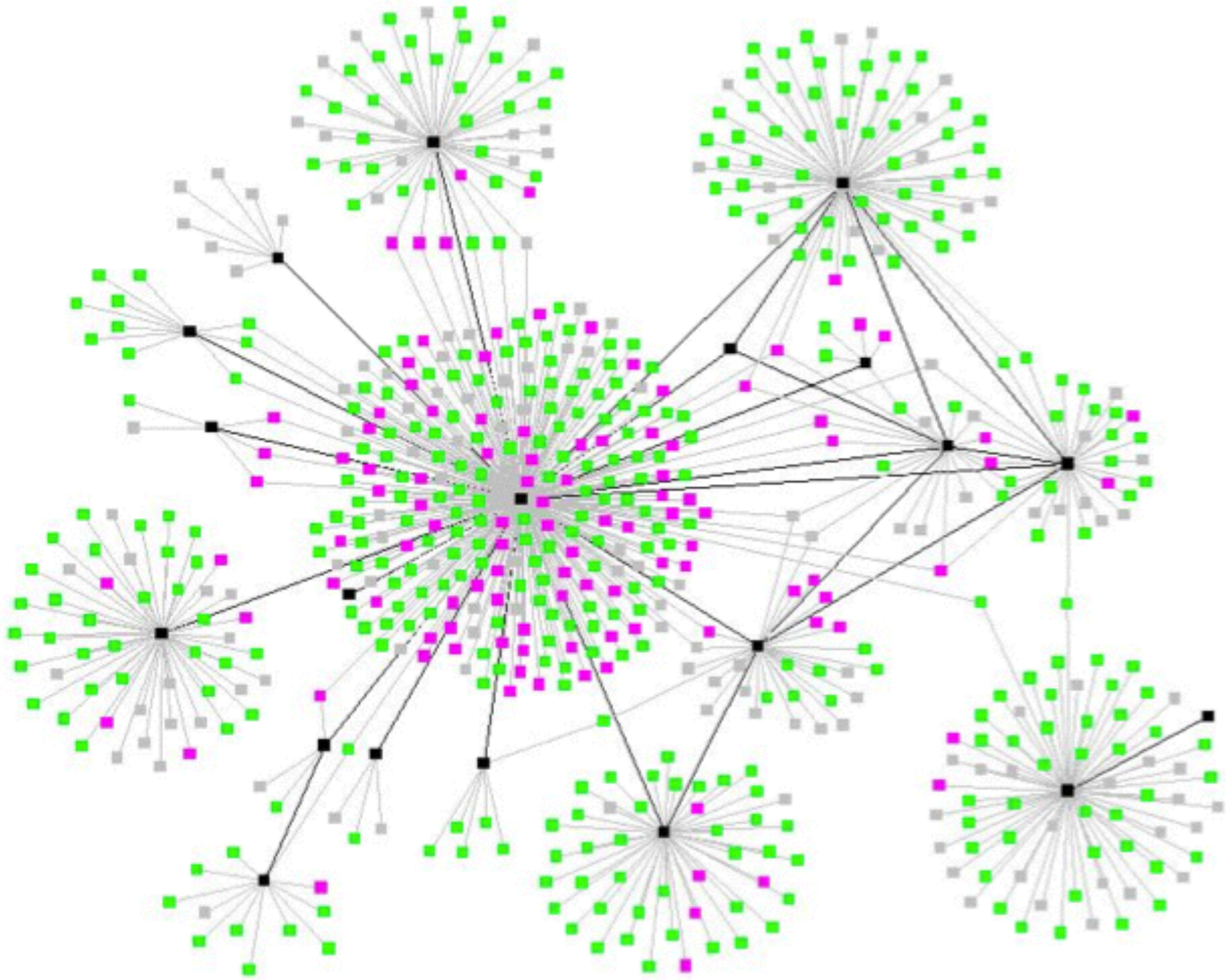
Community detection

- In Karate club network
- What are the groups of friends?
- Who are likely to form alliances?



Spread of *epidemics*

- Diseases spread in a network
- A contagious disease spreads only between along *edges* of a network
- Structure of the network determines how the disease spreads
- Who is susceptible
- Which community is susceptible



Epidemics

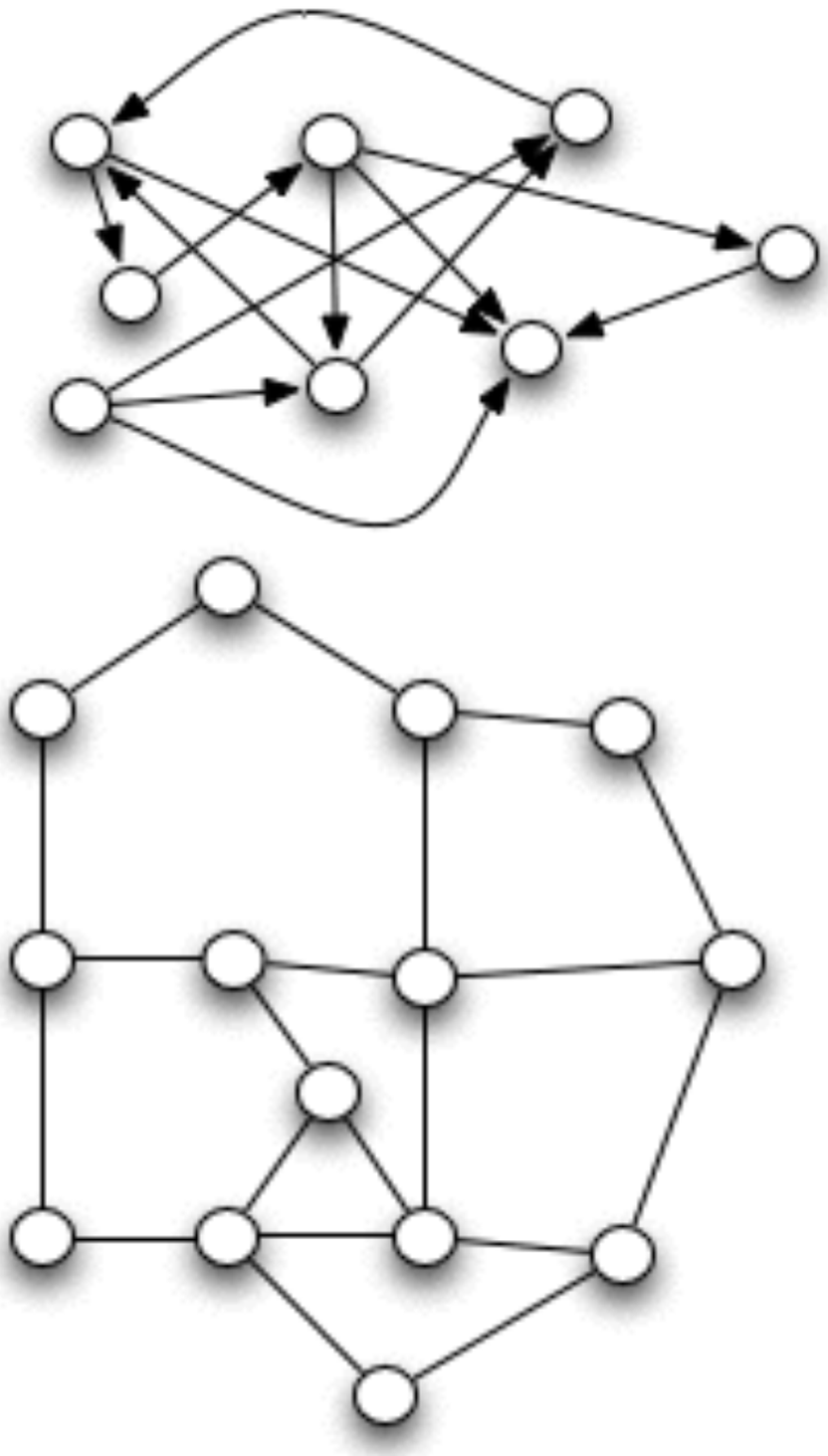
- Spread of trends
  - New fashion, phone, gadget, idea …
  - Word of mouth is more valuable than general advertisement
    - People trust friends' opinion more than ads
    - Endorsement by multiple friends more effective than one
- Network structure affects epidemics
- Certain people are more important than others
- Targeting products/services intelligently can be critical to adoption

Social structures, communities, epidemics

- Network analysis is not a fully solved problem
- We are still trying to understand:
    - Detecting communities
    - Predicting spread of epidemics
    - Predicting who will become friends with who
- Various reasons:
    - Sometimes the problem is difficult to define precisely (e.g. what are communities?)
    - Sometimes we are missing information (who will meet who and become friends)
    - Some solutions are just hard to compute

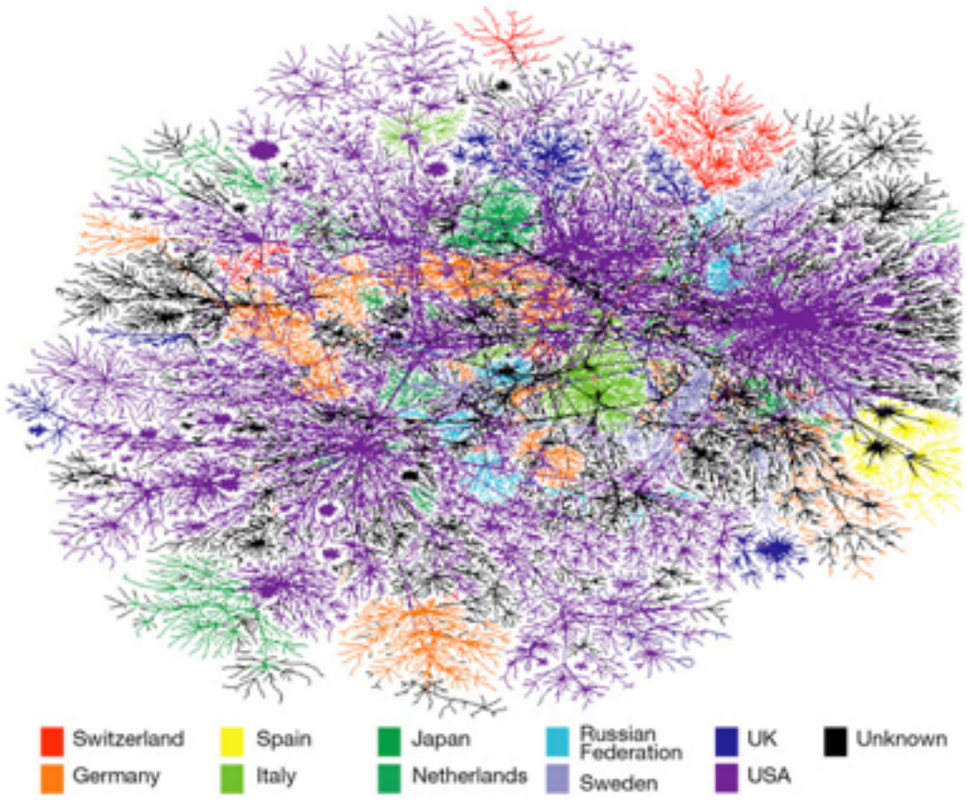
Other networks

- World wide web:
  - Nodes: pages (or sites); Edges : Links
- Road networks:
  - Nodes: Crossings;
    Edges: Road segments



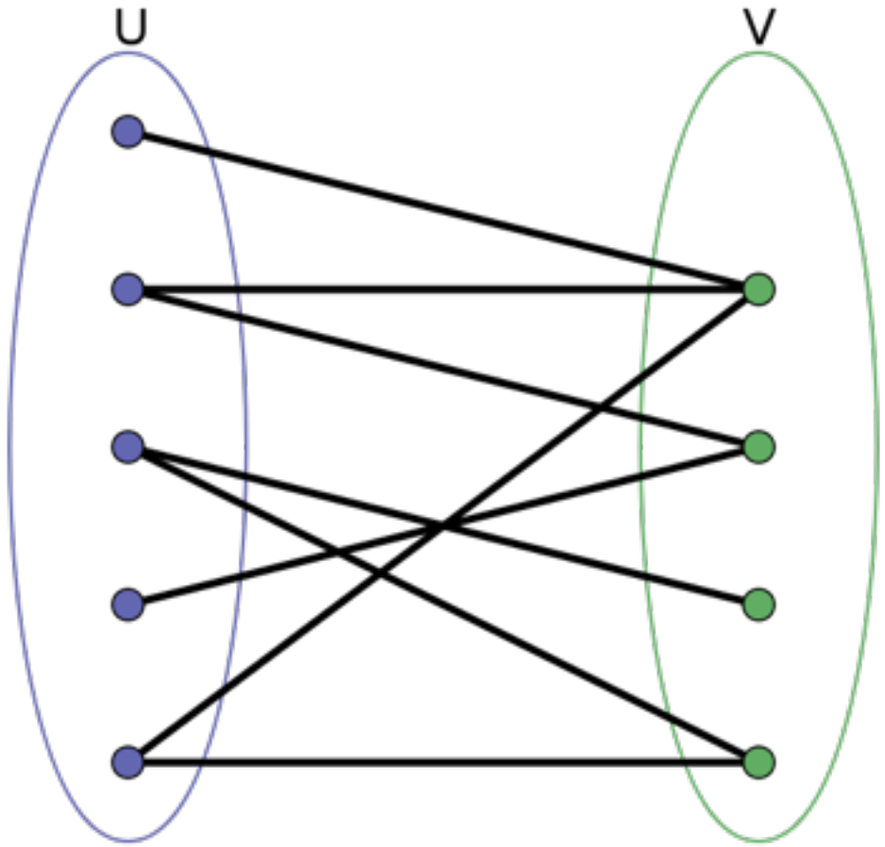
Other networks

- Internet/Computer networks
  - Nodes: Routers/computers; Edges: Network connections (cables, wireless connections)
  - Internet has a densely connected core
  - It has redundancy: hard to bring it down by attacking a few nodes
  - Image from “How robust is the Internet?”, Nature, 2000



Other networks

- Bipartite networks
  - Users and products (e.g. Amazon, Netflix..)
  - Members and clubs
  - …



Other networks

- Networks of communities/groups
  - Nodes: Groups of elements (e.g. people)
  - Edges: Between groups with common memmbers

Other network

- Language
  - How does language change and spread in a network?
    - Suppose we represent words in a network
      - Nodes: Words
      - Edges: Connect similar words
    - What can we say about languages?

Network questions

- How does network structure affect events?
    - Epidemics, formation of friendships, communities…
- Which are the important/influential nodes in a network?
    - Most effect on others
    - Most effect on flow of information
    - Most effective in starting an epidemic
    - Most effective in stopping an epidemic
- What are the communities?
- Which quantities can help us to understand what to expect in a network?
- How can we compute them efficiently?
- How can we efficiently compute important nodes, communities, predict future edges, predict spread of disease etc?

Techniques

- Algorithms, data structures
- Clustering (e.g. community detection)
- Dimension reduction
- Optimization (e.g. influential nodes)
- Linear algebra
- Comparison with Random graphs

Tools

- Model Analysis
- Programming (data analysis)
  - Python or Java or C++
  - IPython notebook
  - Gephi: Graph drawing tool
  - Netlogo: Simulation of networked agents

Course Information

- 14:10; Tuesdays (LT4), Fridays (LT2)
- 60% Written exam
    - Lecture notes, book chapters, parts of papers given in class
    - Exercise problems (not graded) given in class
        - Samples solutions (for some problems) given few days later
- 40% Coursework

Coursework

- 1 Project
- Given in week 4.
- Due Nov 25 (Week 10).
- The project description will contain a general description of the problem. But no details of exactly how to do it.
- Your responsibility is to:
  - Compose a precise problem statement
  - Make sure that the dataset available allows solution to the problem you state
  - Find a solution. May contain one or more of the following steps
    - Analyze network data and find interesting results (python or java or C++)
    - Design an algorithm and apply to network data
    - Theoretically analyze a model
    - etc…

Coursework

- More details will be available soon
- **Main objective of project:**
  - **Play with network data and ideas. Do something new!**
  - **Find your own view on an aspect of networks**

The course

Is not about:

- Facebook (or whatsapp, or Linkedin…)
- Making apps

The course

Is about:

- Understanding mathematical techniques related to networks
- Measures that distinguish structure and behaviors of networks
- Efficient algorithms to compute these
- Models that represent the most important properties of networks
- Recent work and new ideas
- Network science is a new subject, not everything is understood
- Therefore *now* is the time to learn it (before it gets old)

Pre-requisites

- Probability, set theory
- Basic graph theory & Algorithms: Graphs, tress, DFS, BFS, spanning trees, minimum spanning trees, sorting
- Linear algebra.

Linear algebra

- Matrix operations
- Graphs as matrices
- Eigen vectors and eigen values