Complex Networks Introduction

2018.11.29(Thu)

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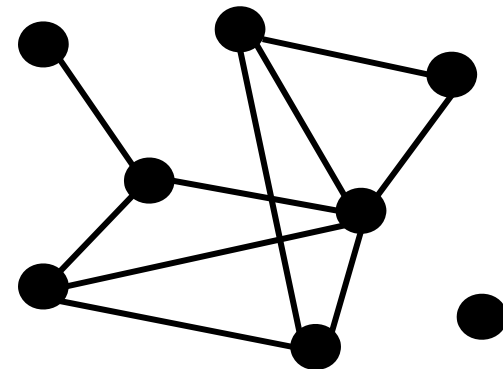- properties of networks

Definition

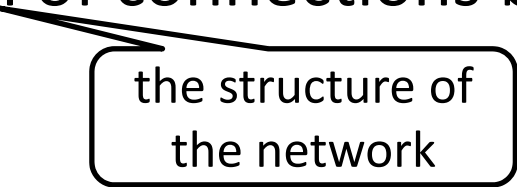- a collection of points joined together in pairs by lines

  vertices, nodes

  edges

- many objects in physical, biological, and social sciences can be thought of as networks

Why important?

- individual parts or components in many systems are linked together

- many aspects are worthy of study
  - the nature of individual components
    - how a computer works
  - the nature of connections or interactions
    - communication protocols on the Internet
  - the pattern of connections between components

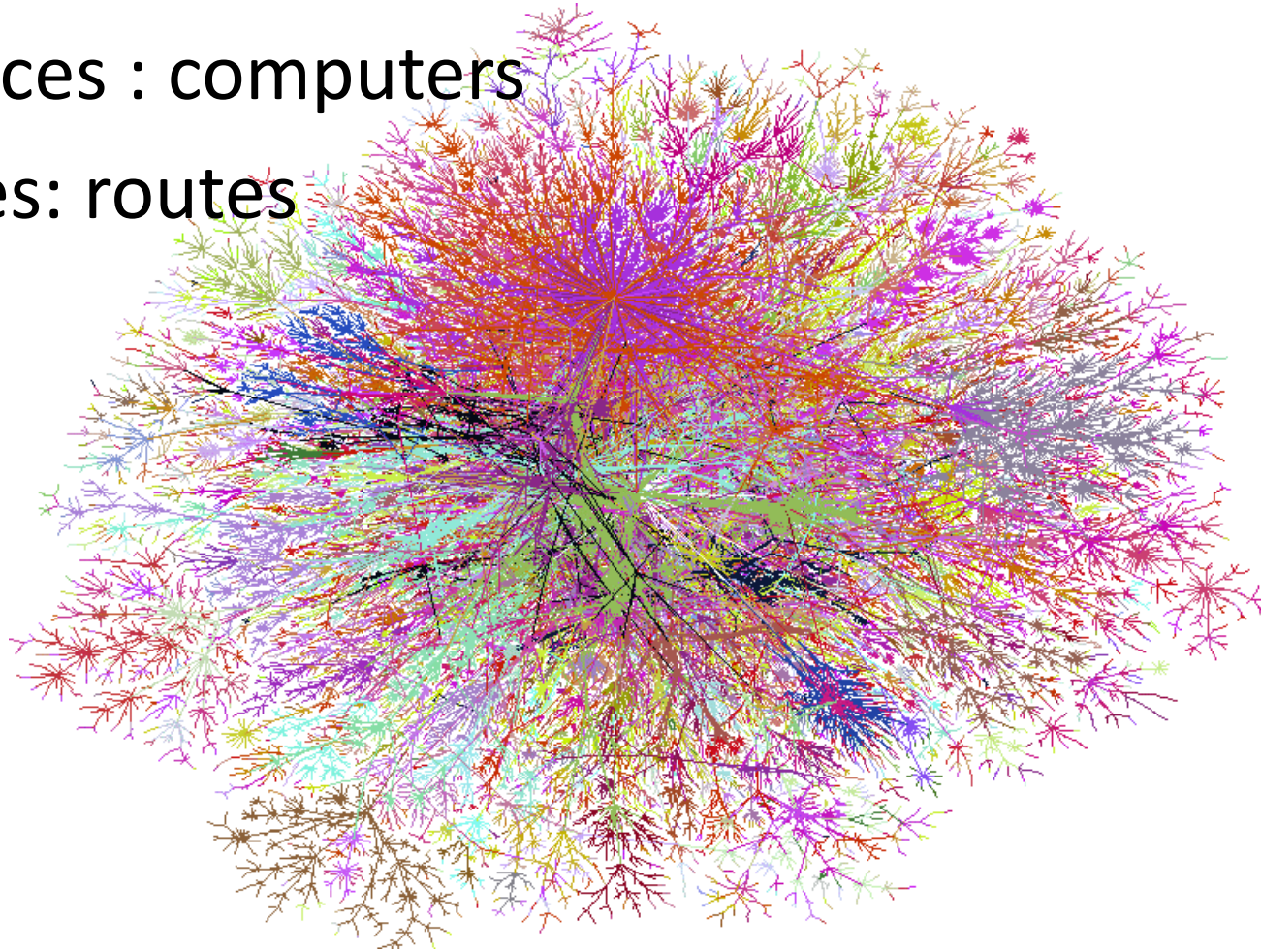   the structure of the network

Examples - Facebook

- On Facebook, the average user is only 4.74 degrees away from any other Facebooker.

http://edition.cnn.com/2011/11/22/tech/social-media/facebook-six-degrees/index.html
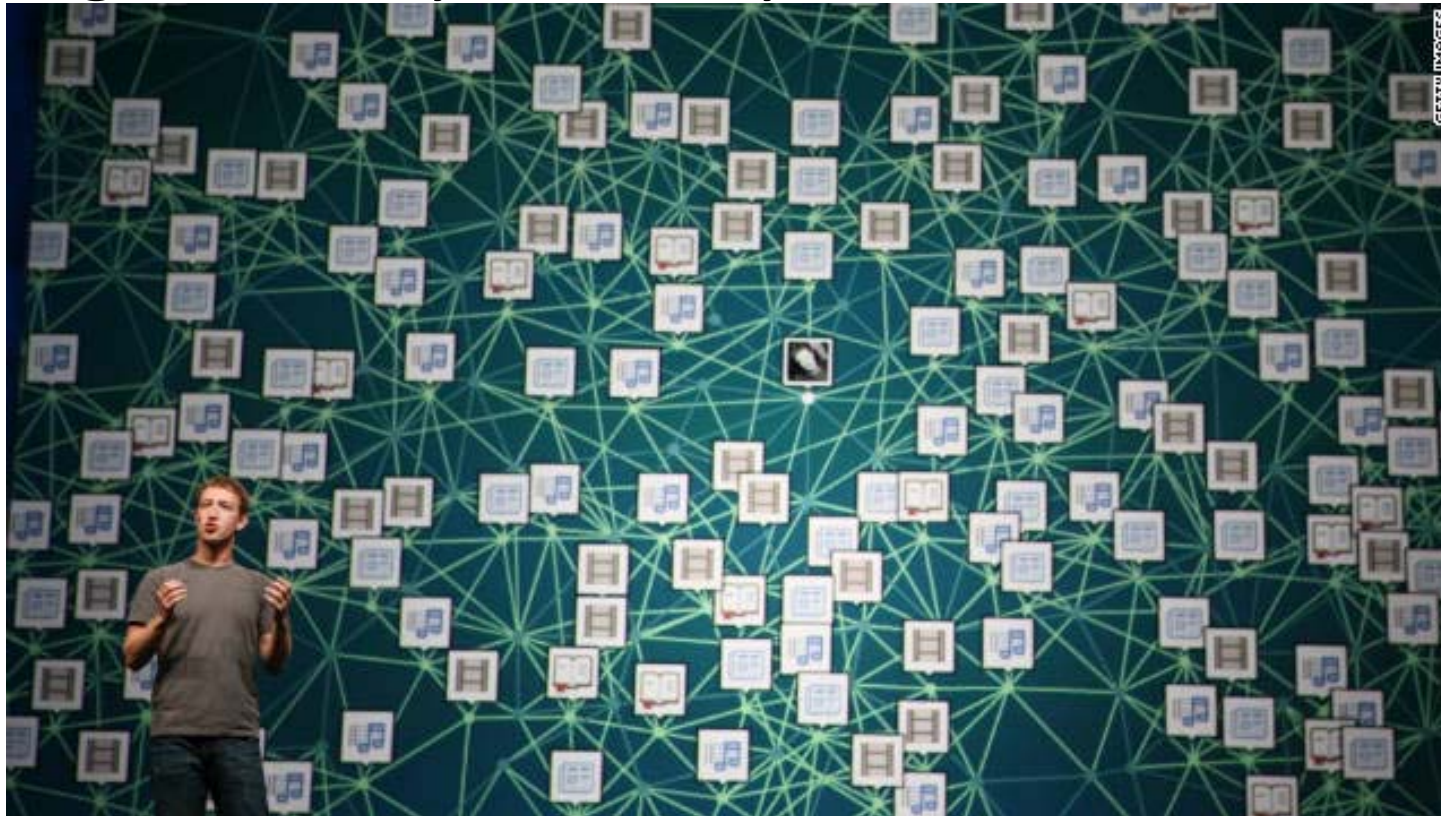
Examples- Internet
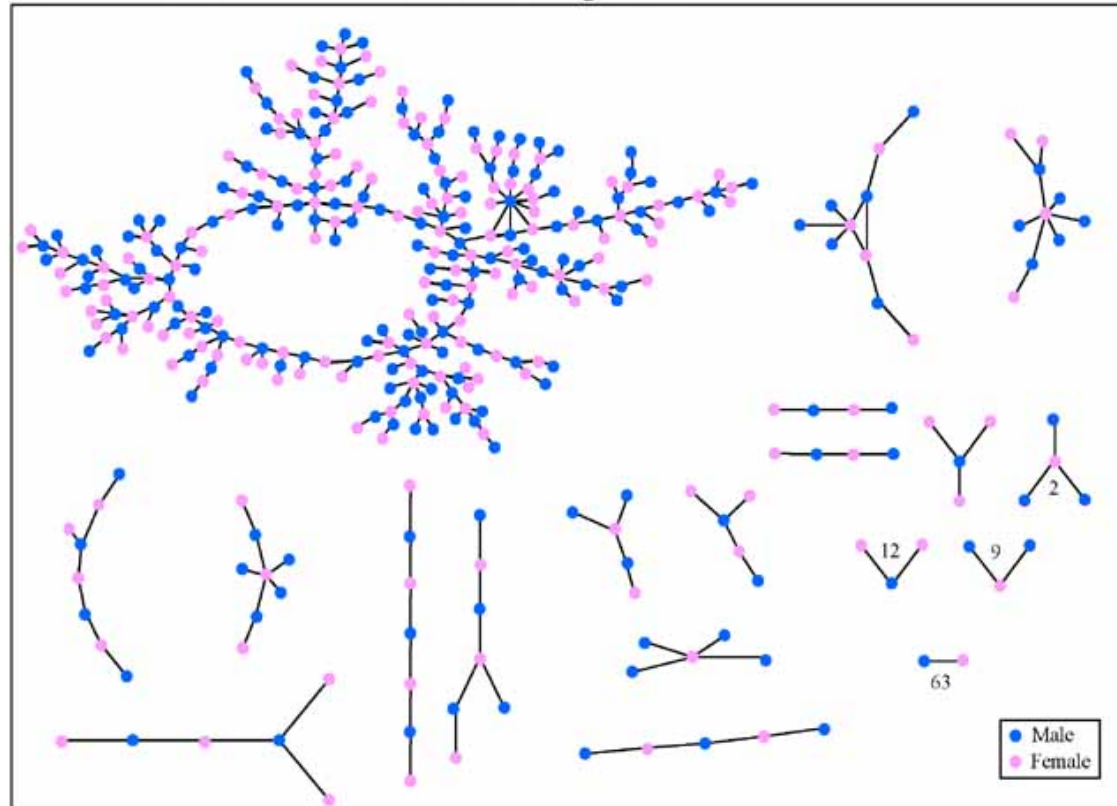
- vertices : computers

- edges: routes

William R. Cheswick, http://www.cs.bell-labs.com/~ches/map/index.html

Examples-social network

- vertices: boys & girls
- edges: romantic relations

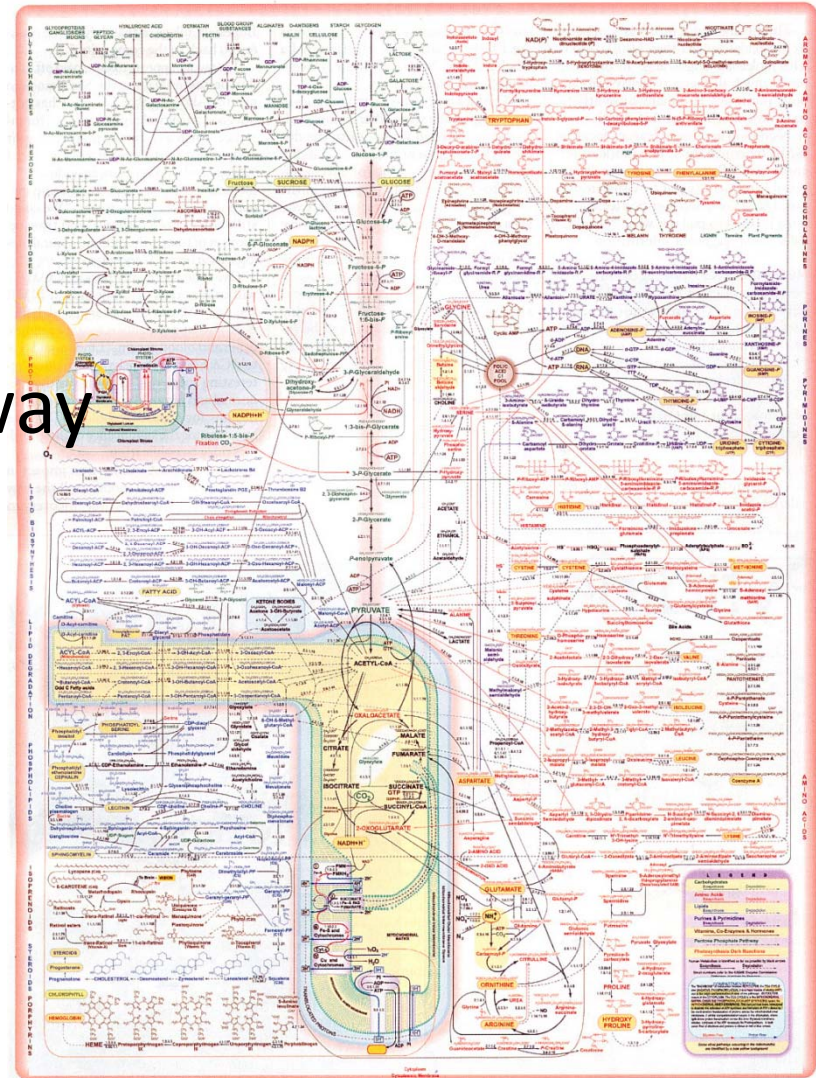The Structure of Romantic Relations at "Jefferson High School"

Each circle represents a student and lines connecting students represent romantic relations occuring within the 6 months preceding the interview. Numbers under the figure count the number of times that pattern was observed (i.e. we found 63 pairs unconnected to anyone else).

http://researchnews.osu.edu/archive/chainspix.htm

Example-metabolic network

- vertices: carbohydrase, amino acid, lipid
- edges: metabolic pathway

Donald Nicholson, http://www.iubmb-nicholson.org/chart.html

Example-food web

- vertices: species in a lake in northern US
- edges: predatory interactions
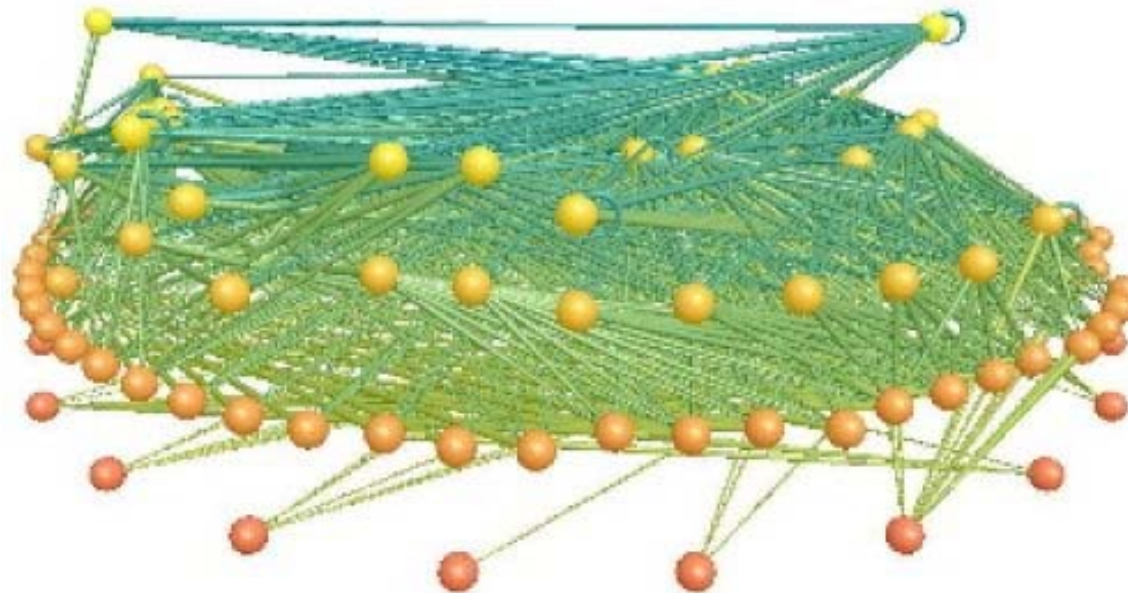
You will find …

- non-uniform: mixture of dense / sparse parts
- inherent structures: bipartite, hierarchical, …
- heterogeneous : many types of nodes / edges
  - nodes : boys/girls, amino acids, …
  - edges : typed (positive/negative) / directed / weighted / probabilistic, …
- incomplete: missing/erroneous nodes/edges
  - Some networks are dynamically changing
  - Some parts are missing / unobservable

What are the challenges?

- metrics
  - Because of heterogeneity, some metrics are not available
  - New metrics should be introduced for some networks
- algorithms
  - How can we compute with huge/tiny networks efficiently/accurately?
    - finding groups/communities in networks
    - predicting the future of dynamic networks
    - selecting central/influential nodes, critical edges
- models
  - How can we generate similar networks?
    - scale-free, small world, power law, …
- processes
  - Influence maximization (information) / minimization (disease)
  - detecting key persons/pathways for diffusion

Questions about the networks

- What can we do with the network?
- What can they tell us about the form and functions of the system the network represents?
- What properties of networked systems can we measure or model and how are those properties related to the practical issues we care about?