The Internet

- How valuable is a network?
  - Metcalfe's Law
- Domain Name System: translates between names and IP addresses
- Properties of the Internet
  - Heterogeneity
  - Redundancy
  - Packet-switched
  - 1.08 billion online (Computer Industry Almanac 2005)
- Warriors of the Net!
- Who has access?
- How important is access?

Tim Berners-Lee

I want you to realize that, if you can imagine a computer doing something, you can program a computer to do that. Unbounded opportunity... limited only by your imagination. And a couple of laws of physics.

- TCP/IP, HTTP
  - How, Why, What, When?

Graphs: Structures and Algorithms

- How do packets of bits/information get routed on the internet
  - Message divided into packets on client (your) machine
  - Packets sent out using routing tables toward destination
    - Packets may take different routes to destination
    - What happens if packets lost or arrive out-of-order?
  - Routing tables store local information, not global (why?)
- What about The Oracle of Bacon, Erdos Numbers, and Word Ladders?
  - All can be modeled using graphs
  - What kind of connectivity does each concept model?
- Graphs are everywhere in the world of algorithms (world?)

Vocabulary

- Graphs are collections of vertices and edges (vertex also called node)
  - Edge connects two vertices
    - Direction can be important, directed edge, directed graph
    - Edge may have associated weight/cost
- A vertex sequence $v_0, v_1, ..., v_{n-1}$ is a path where $v_k$ and $v_{k+1}$ are connected by an edge.
  - If some vertex is repeated, the path is a cycle
  - A graph is connected if there is a path between any pair of vertices
Network/Graph questions/algorithms

- What vertices are reachable from a given vertex?
  - Two standard traversals: depth-first, breadth-first
  - Find connected components, groups of connected vertices

- Shortest path between any two vertices (weighted graphs?)!

- Longest path in a graph
  - No known efficient algorithm
  - Longest shortest path: Diameter of graph

- Visit all vertices without repeating? Visit all edges?
  - With minimal cost? Hard!

- What are the properties of the network?
  - Structural: Is it connected?
  - Statistical: What is the average number of neighbors?

Network Nature of Society

- Slides from Michael Kearns - Univ. of Pennsylvania

Emerging science of networks

- Examining apparent similarities between many human and technological systems & organizations
- Importance of network effects in such systems
- How things are connected matters greatly
- Structure, asymmetry and heterogeneity
- Details of interaction matter greatly
- The metaphor of viral spread
- Dynamics of economic and strategic interaction
- Qualitative and quantitative; can be very subtle
- A revolution of
  - measurement
  - theory
  - breadth of vision

Business & Economic Networks

- Example: eBay bidding
  - vertices: eBay users
  - links: represent bidder-seller or buyer-seller
  - fraud detection: bidding rings
- Example: corporate boards
  - vertices: corporations
  - links: between companies that share a board member
- Example: corporate partnerships
  - vertices: corporations
  - links: represent formal joint ventures
- Example: goods exchange networks
  - vertices: buyers and sellers of commodities
  - links: represent “permissible” transactions
Physical Networks

- Example: the Internet
  - vertices: Internet routers
  - links: physical connections
  - vertices: Autonomous Systems (e.g. ISPs)
  - links: represent peering agreements
  - latter example is both physical and business network
- Compare to more traditional data networks
- Example: the U.S. power grid
  - vertices: control stations on the power grid
  - links: high-voltage transmission lines
  - August 2003 blackout: classic example of interdependence

Content Networks

- Example: Document similarity
  - Vertices: documents on web
  - Edges: Weights defined by similarity
  - See TouchGraph GoogleBrowser
- Conceptual network: thesaurus
  - Vertices: words
  - Edges: synonym relationships
Social networks

- **Example: Acquaintanceship networks**
  - vertices: people in the world
  - links: have met in person and know last names
  - hard to measure

- **Example: scientific collaboration**
  - vertices: math and computer science researchers
  - links: between coauthors on a published paper
  - Erdos numbers: distance to Paul Erdos
  - Erdos was definitely a hub or connector; had 507 coauthors

- How do we navigate in such networks?

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Acquaintanceship & more

- Network Models (Barabasi)
  - Differences between Internet, Kazaa, Chord
    - Building, modeling, predicting
  - Static networks, Dynamic networks
    - Modeling and simulation
  - Random and Scale-free
    - Implications?
  - Structure and Evolution
    - Modeling via Touchgraph
Web-based social networks

http://trust.mindswap.org

- Myspace 73,000,000
- Passion.com 23,000,000
- Friendster 21,000,000
- Black Planet 17,000,000
- Facebook 8,000,000

- Who’s using these, what are they doing, how often are they doing it, why are they doing it?

Golbeck’s Criteria

- Accessible over the web via a browser
- Users explicitly state relationships
  - Not mined or inferred
- Relationships visible and browsable by others
  - Reasons?
- Support for users to make connections
  - Simple HTML pages don’t suffice