

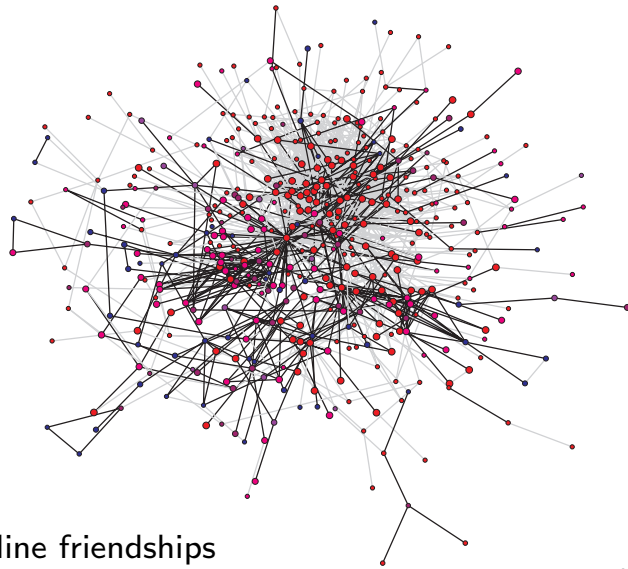
# Networks, Crowds, and Markets: Reasoning about a Highly Connected World

David Easley and Jon Kleinberg

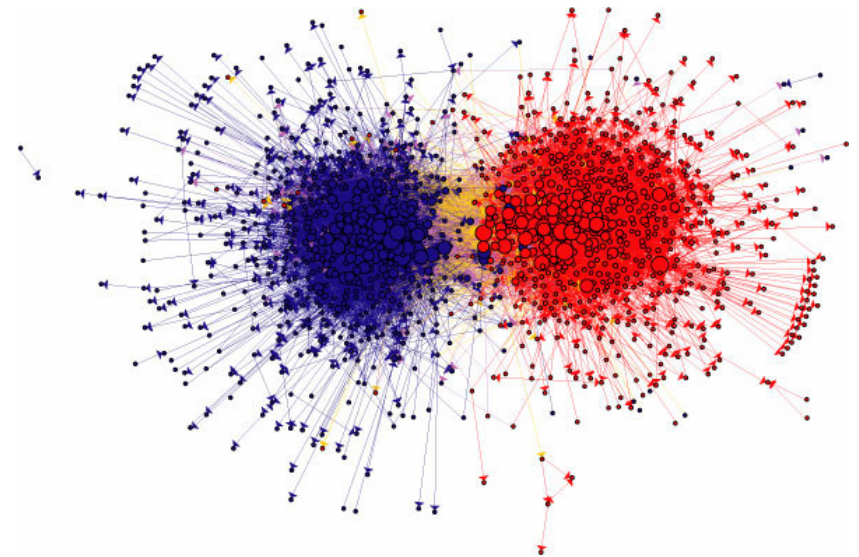
Cornell University



# Students in the Information Age



On-line friendships  
(Backstrom-Huttenlocher-Kleinberg-Lan 2006)



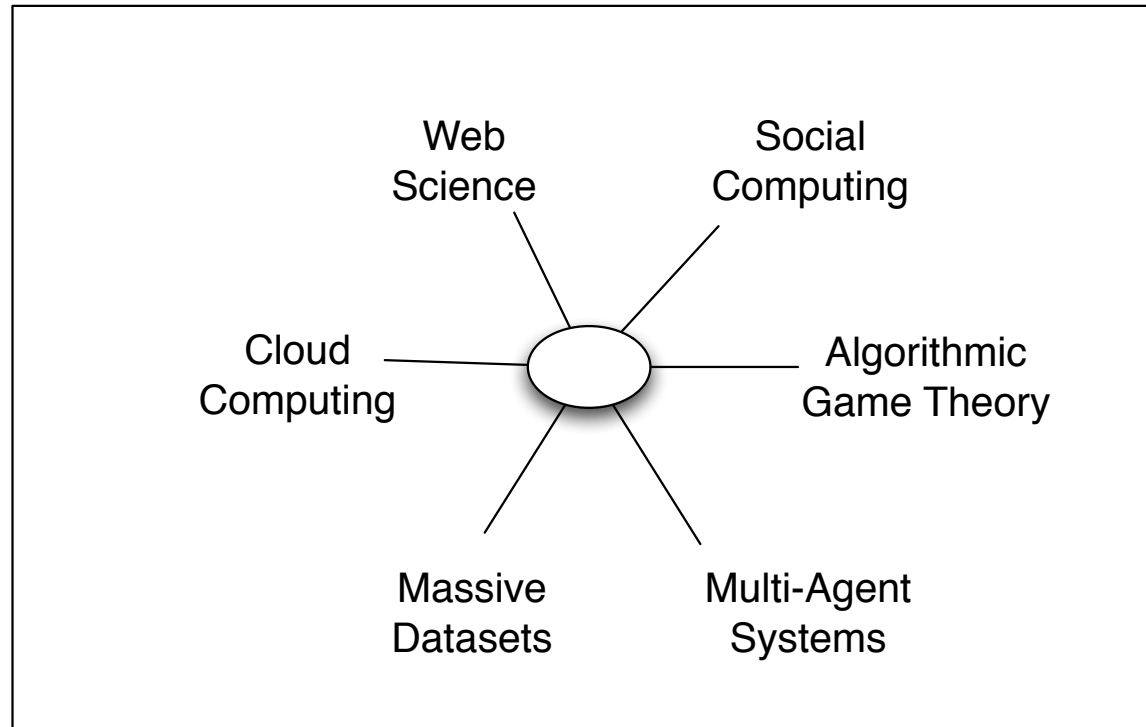
Political blogs (Adamic and Glance, 2005)

Students entering college are immersed in computing:  
It's part of the fabric of their everyday experience as never before.

An opportunity: Convey to students from all areas some of the intellectual underpinnings of the Information Age.

- Computational thinking in a particular setting, combined with social and economic principles.

# An Inter-Disciplinary Area in Computing

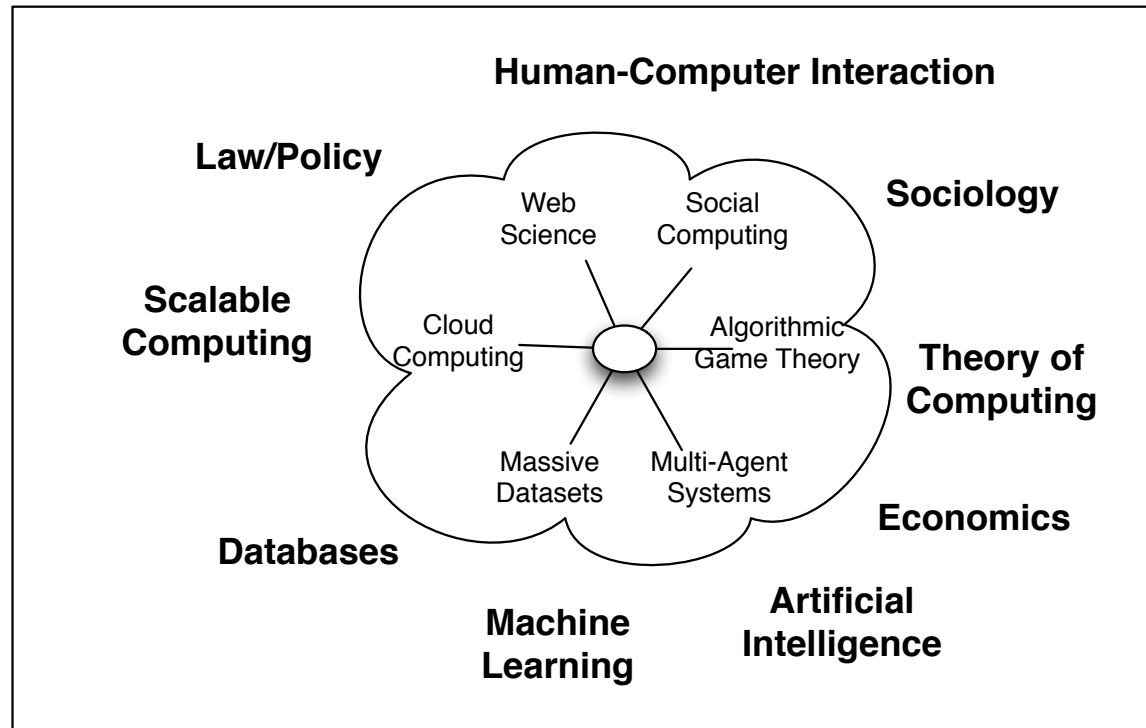


Focus on the nexus of social and information networks.

- Growing activity in academia and industrial research.
- New NSF initiatives (Socially Intelligent Computing; Interface of CS, Econ, and the Social Sciences).

Touches on theory, systems, AI, with scientific foundations also rooted in economics and sociology.

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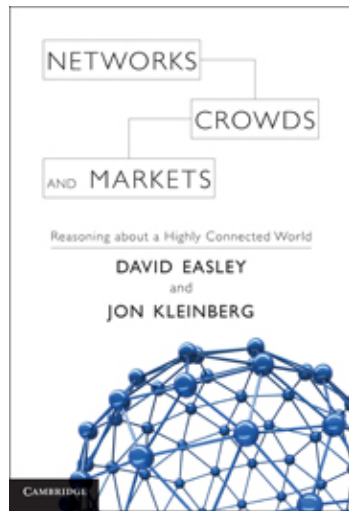


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# Networks, Crowds, and Markets



- Seeks to capture area's scientific foundations.
- Book in print as of July 2010 (Camb. U. Press).
- Complete pre-print on-line at [www.cs.cornell.edu/home/kleinber/networks-book/](http://www.cs.cornell.edu/home/kleinber/networks-book/)
- Co-authored with David Easley (Cornell Dept. of Economics)

Book based on an introductory freshman-level course at Cornell.

- Drafts of the book have since been used at Caltech, Carleton, CMU, Duke, MIT, Michigan, Northwestern, Stanford, U. Maryland, ...; in depts. of CS, Comm, Econ, Mgmt Sci and schools of Business and Info.

At Cornell:

- First offered in 2007 (related: Michael Kearns's *Networked Life* at Penn).
- Most recent Cornell offering in 2010
  - > 450 students from 45 different majors

# Majors Represented (Spring 2010)

Animal Science, Applied Economics and Mgmt, Architecture, Asian Studies, Atmospheric Sciences, Biological Engineering, Biological Sciences, Biology and Society, Biometry & Statistics, Chemical Engineering, Chemistry and Chemical Biology, Civil Engineering, Communication, Computer Science, Development Sociology, Economics, Electrical and Computer Engr, Engineering Physics, English, Entomology, Environmental Engr, Fine Arts, Food Science, Government, History, Hotel and Restaurant Admin, Human Development Studies, Industrial and Labor Relations, Information Science, Landscape Architecture, Law, Materials Science and Engr, Mathematics, Mechanical Engineering, Natural Resources, Near Eastern Studies, Operations Research & Engineering, Philosophy, Physics, Plant Sciences, Policy Analysis and Management, Psychology, Science of Earth Systems, Sociology, Urban & Regional Studies

## Majors with at least 4 students (Spring 2010)

Animal Science, Applied Economics and Mgmt, Architecture, Asian Studies, Atmospheric Sciences, Biological Engineering, Biological Sciences, Biology and Society, Biometry & Statistics, Chemical Engineering, Chemistry and Chemical Biology, Civil Engineering, Communication, Computer Science, Development Sociology, Economics, Electrical and Computer Engr, Engineering Physics, English, Entomology, Environmental Engr, Fine Arts, Food Science, Government, History, Hotel and Restaurant Admin, Human Development Studies, Industrial and Labor Relations, Information Science, Landscape Architecture, Law, Materials Science and Engr, Mathematics, Mechanical Engineering, Natural Resources, Near Eastern Studies, Operations Research & Engineering, Philosophy, Physics, Plant Sciences, Policy Analysis and Management, Psychology, Science of Earth Systems, Sociology, Urban & Regional Studies

# Target Audience

With respect to CS, can think of this audience in three parts.

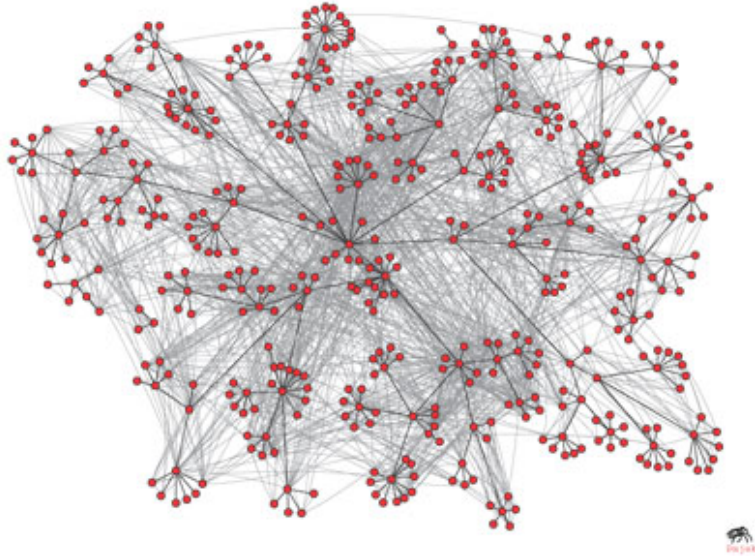
- Computer science majors: things they should know outside the standard curriculum if they're going to work at Google, Yahoo!, Microsoft, Amazon, ...
- Students with computing interests who then think of CS or Information Science as a potential major/minor.
- By far the largest group: students who had no intention of taking a course on computing.

Reaching this third group is an opportunity.

- What will be our analogue of intro psych / intro econ / intro political science?
- Our course: a version of this using current topics, on a foundation of CS, economics, and sociology.
- Other models are possible (e.g. "Blown to Bits").



# Theme: Reasoning about a Highly Connected World



Corporate e-mail communication  
(Adamic and Adar, 2005)



Query volume for YouTube 2006-2008  
(Google Trends)

Connectivity at the level of structure:

- Social networks, hyperlink networks, interacting components.

Connectivity at the level of behavior:

- Each person's actions have consequences for everyone else.
- Population-level effects: Tragedy of the Commons, Wisdom of Crowds, The Long Tail.

# Outline of Topics

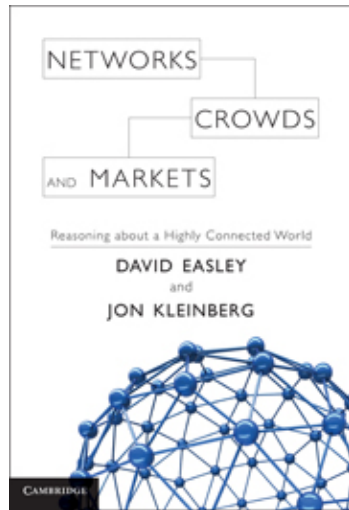
- (1) Graph Theory
  - basic network structure, ideas from social networks
- (2) Game Theory
  - strategic behavior; examples from auctions, traffic
- (3) Strategic Interaction on Networks
  - markets, matchings, bargaining, and power
- (4) Information Networks and the Web
  - Web structure, Web search, sponsored search markets
- (5) Network dynamics: population models
  - information cascades, rich-get-richer, power laws
- (6) Network dynamics: structural models
  - cascading behavior, small-world phenomena, epidemics
- (7) Institutions and Aggregate Behavior
  - markets and information, voting, property rights

# Computer Science Themes

The book and course highlight a range of CS ideas.

- Algorithms: breadth-first search, strongly connected components, bipartite matching, weighted assignment.
- Algorithmic game theory: traffic and congestion, design of auctions and truthful mechanisms, sponsored search.
- Architecture of the Web: the idea of associative memory, search engines (crawl/index/process queries/advertise).
- Social computing: reputation systems, recommendation systems, ranking systems, prediction markets.
- Analyzing network datasets: community detection, hubs/authorities/PageRank.
- Multi-agent systems: modeling systems of interacting agents, modeling agents as Bayesian reasoners.

# Final Reflections



The scientific foundations of the information age are going to involve a blend of many areas, with computing as a central component.

An opportunity to reach many students for whom this will be their only college-level exposure to ideas from computing.

- Fundamental scientific principles relevant to the everyday experiences of students.
- An opportunity to address the scientifically-inclined public (ideas behind the Tipping Point, the Long Tail, Web 2.0, ... )
- A pathway into deeper ideas in computing.