Semester projects

Complex Networks
CSYS/MATH 303, Spring, 2011

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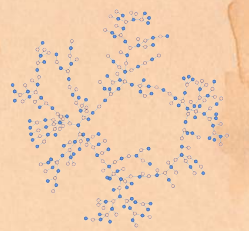
Center for Complex Systems
Vermont Advanced Computing Center
University of Vermont



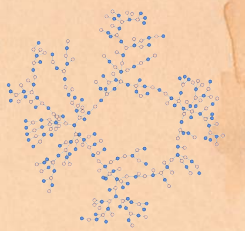
Outline

The Plan

Narrative hierarchy

Suggestions for Projects

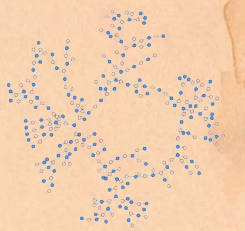
References



Semester projects

Requirements:

1. $\approx$ 5 minute introduction to project (fourth week)
2. 15 minute final presentation
3. Report: $\geq$ 4–5 pages (single space), journal-style



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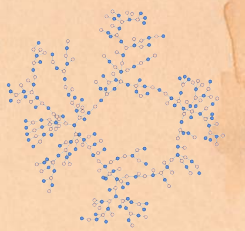

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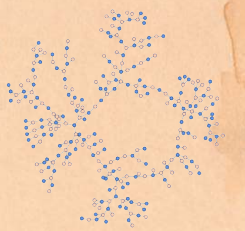
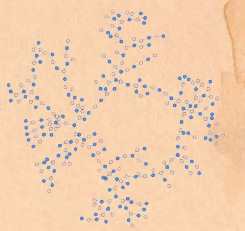


Narrative hierarchy

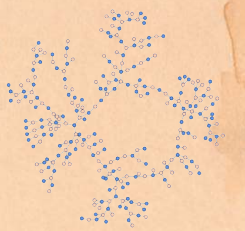
Presenting at many scales:

- 1 to 3 word encapsulation, a sound bite,
- a sentence/title,
- a few sentences,
- a paragraph,
- a short paper,
- a long paper,
- . . .



topics

- Develop and elaborate an online experiment to study some aspect of social networks
- e.g., collective search, cooperation, cheating, influence, creation, decision-making, etc.
- Part of the PLAY project.



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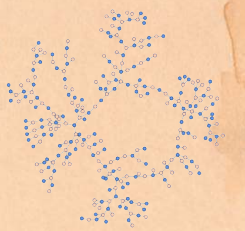

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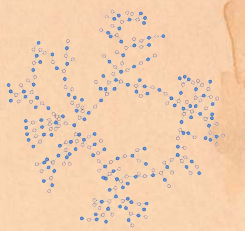


topics

Explore and critique Fowler and Christakis et al. work on social contagion of:

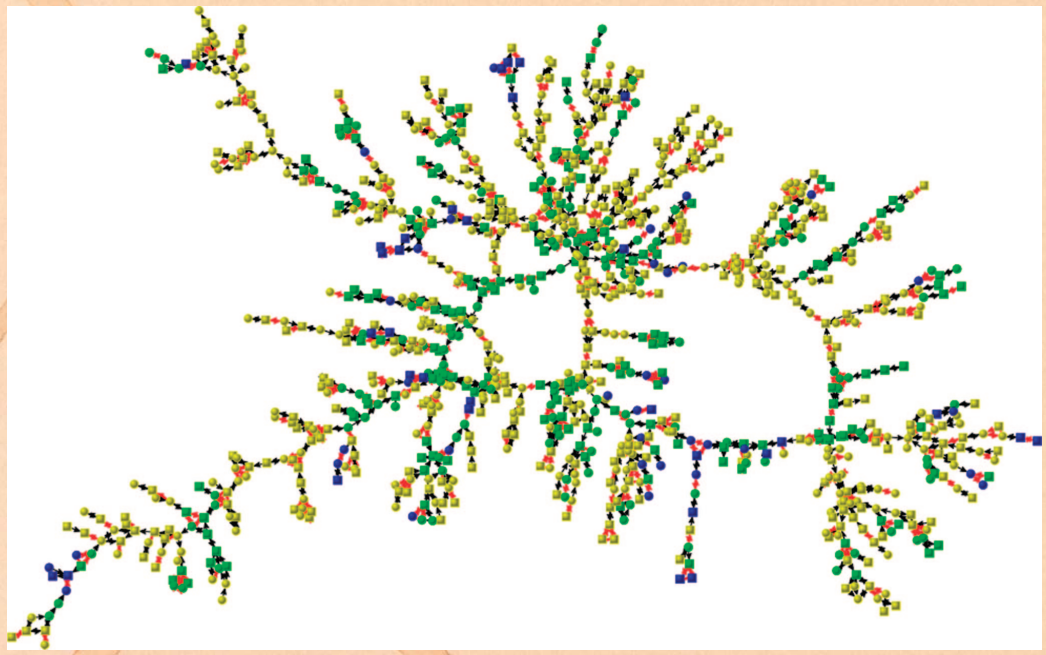
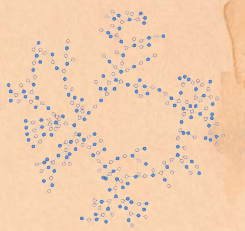


Figure 1. Loneliness clusters in the Framingham Social Network. This graph shows the largest component of friends, spouses, and siblings at Exam 7 (centered on the year 2000). There are 1,019 individuals shown. Each node represents a participant, and its shape denotes gender (circles are female, squares are male). Lines between nodes indicate relationship (red for siblings, black for friends and spouses). Node color denotes the mean number of days the focal participant and all directly connected (Distance 1) linked participants felt lonely in the past week, with yellow being 0–1 days, green being 2 days, and blue being greater than 3 days or more. The graph suggests clustering in loneliness and a relationship between being peripheral and feeling lonely, both of which are confirmed by statistical models discussed in the main text.

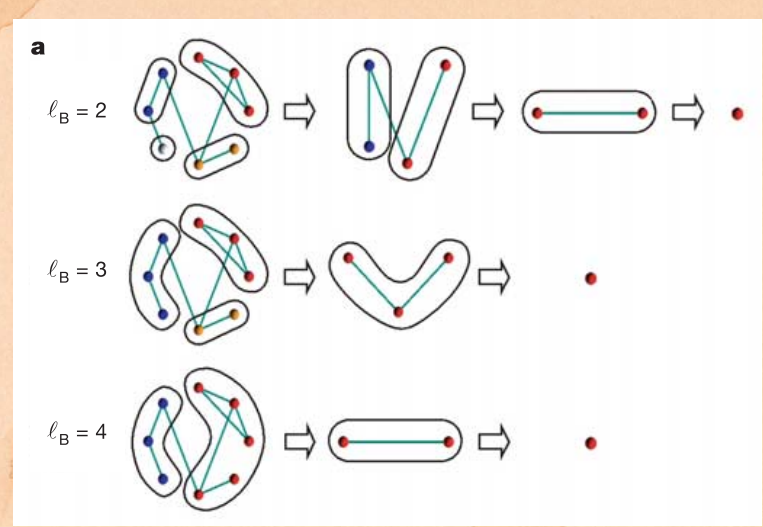
- Obesity [6]
- Smoking cessation [7]
- Happiness [10]
- Loneliness [4]

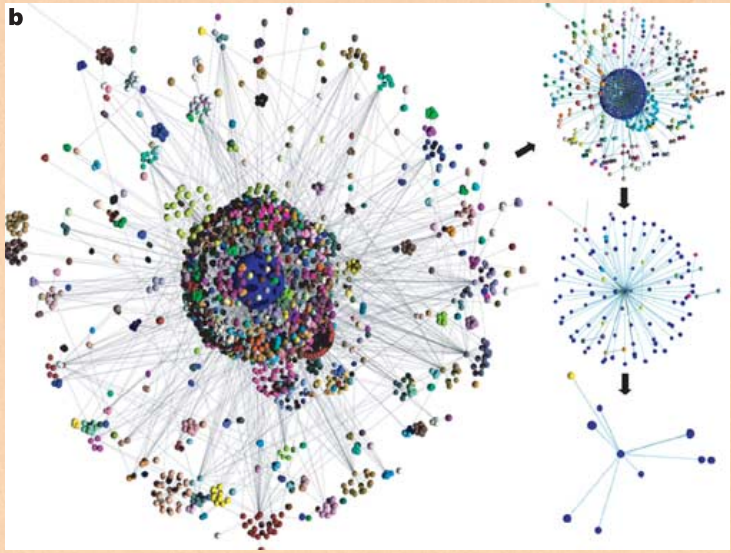


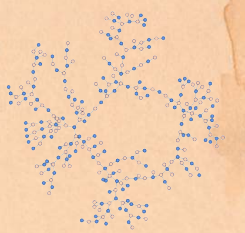
One question: how does the (very) sparse sampling of a real social network affect their findings?

topics

- Explore “self-similarity of complex networks” [21, 22] First work by Song *et al.*, Nature, 2005.
- See accompanying comment by Strogatz [23]

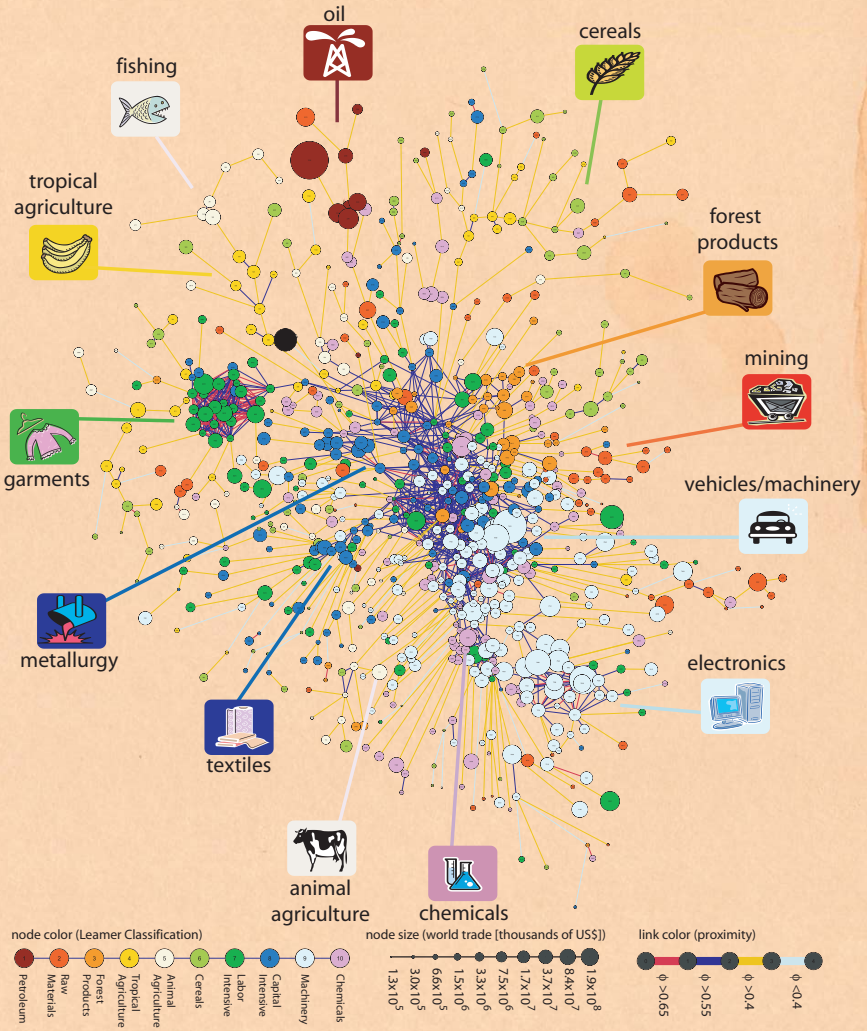


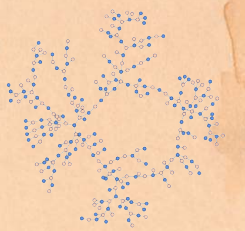




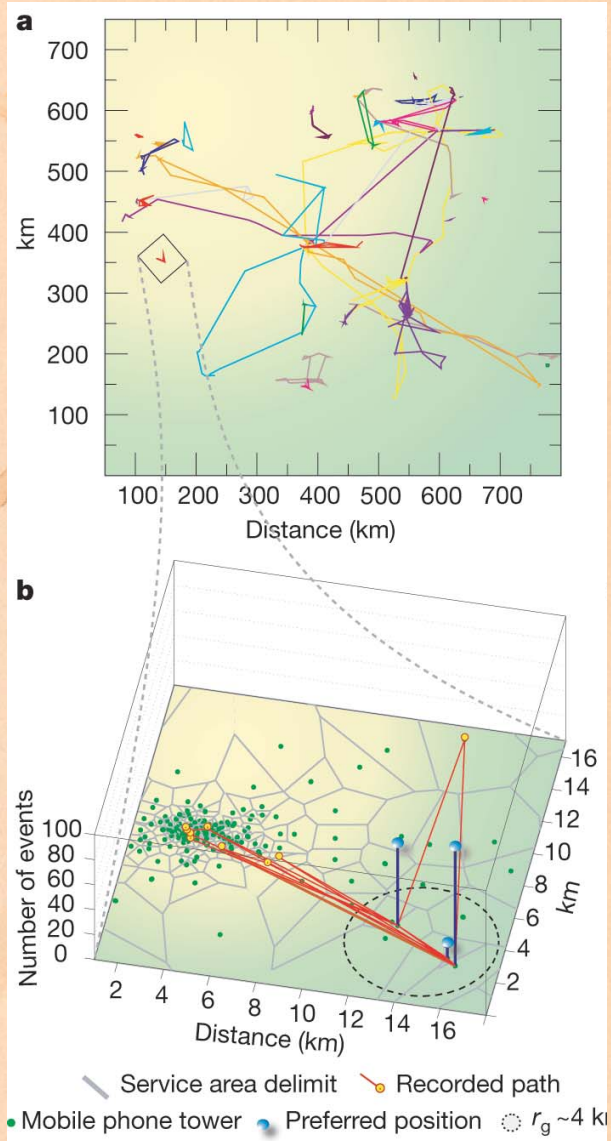
topics

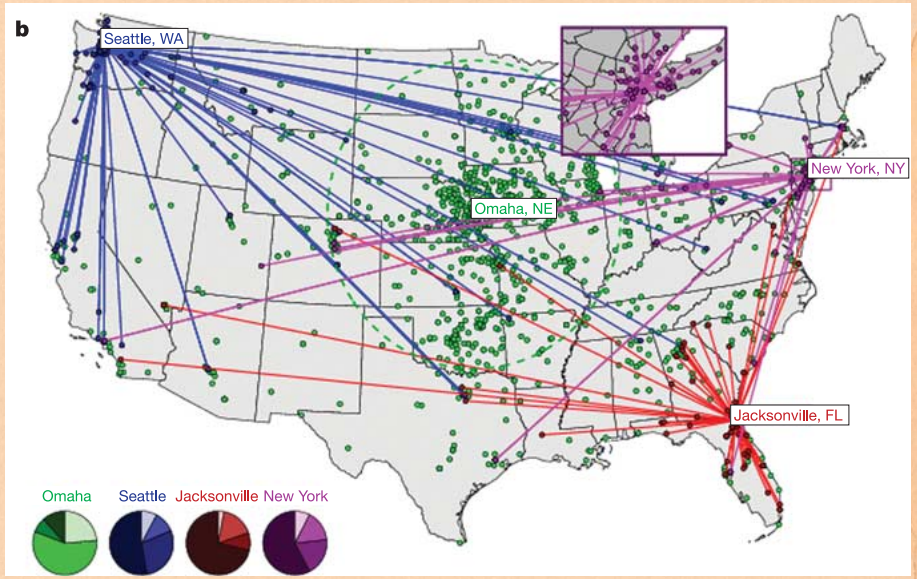
- Study Hidalgo et al.'s "The Product Space Conditions the Development of Nations" [13]
- How do products depend on each other, and how does this network evolve?



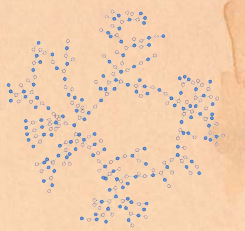


topics





- Study movement and interactions of people.
- Brockmann *et al.* [2] "Where's George" study.
- Barabasi's group: tracking movement via cell phones [11].



topics:

Explore “Catastrophic cascade of failures in interdependent networks” Buldyrev et al., Nature 2010 [3].

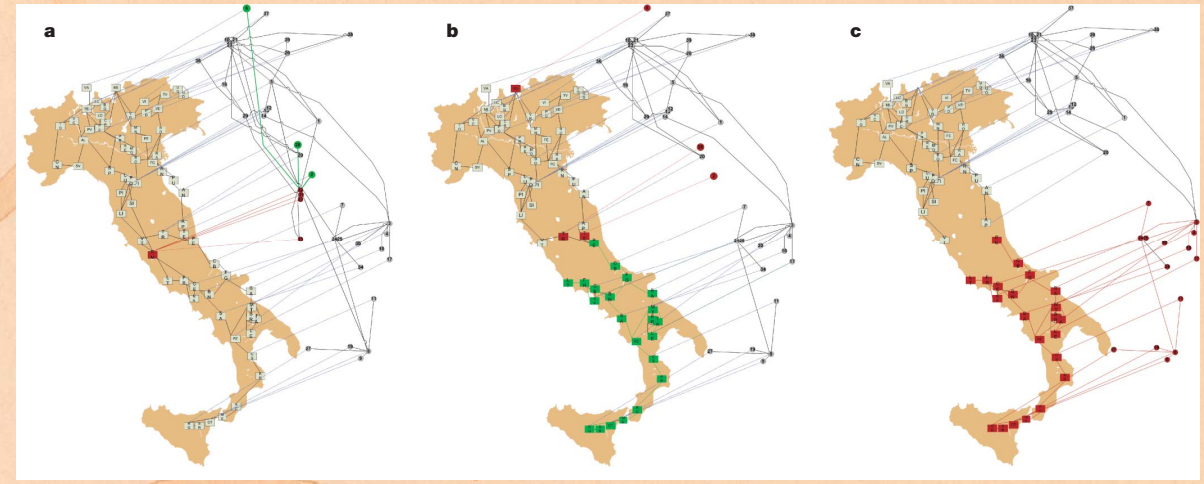
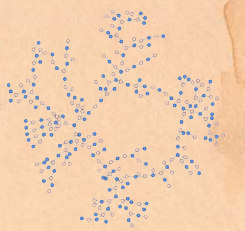


Figure 1 | Modelling a blackout in Italy. Illustration of an iterative process of a cascade of failures using real-world data from a power network (located on the map of Italy) and an Internet network (shifted above the map) that were implicated in an electrical blackout that occurred in Italy in September 2003[20]. The networks are drawn using the real geographical locations and every Internet server is connected to the geographically nearest power station. **a**, One power station is removed (red node on map) from the power network and as a result the Internet nodes depending on it are removed from the Internet network (red nodes above the map). The nodes that will be disconnected from the giant cluster (a cluster that spans the entire network) at the next step are marked in green. **b**, Additional nodes that were disconnected from the Internet communication network giant component are removed (red nodes above map). As a result the power stations depending on them are removed from the power network (red nodes on map). Again, the nodes that will be disconnected from the giant cluster at the next step are marked in green. **c**, Additional nodes that were disconnected from the giant component of the power network are removed (red nodes on map) as well as the nodes in the Internet network that depend on them (red nodes above map).



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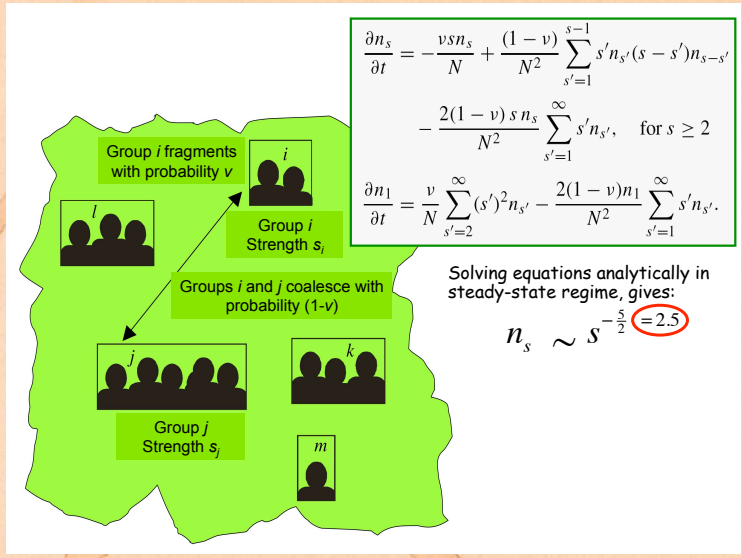
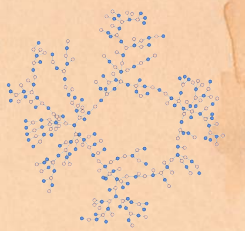


- Physics/Society—Wars: Study work that started with Lewis Richardson's "Variation of the frequency of fatal quarrels with magnitude" in 1949.
- Specifically explore Clauset et al. and Johnson et al.'s work [8, 14, 1] on terrorist attacks and civil wars



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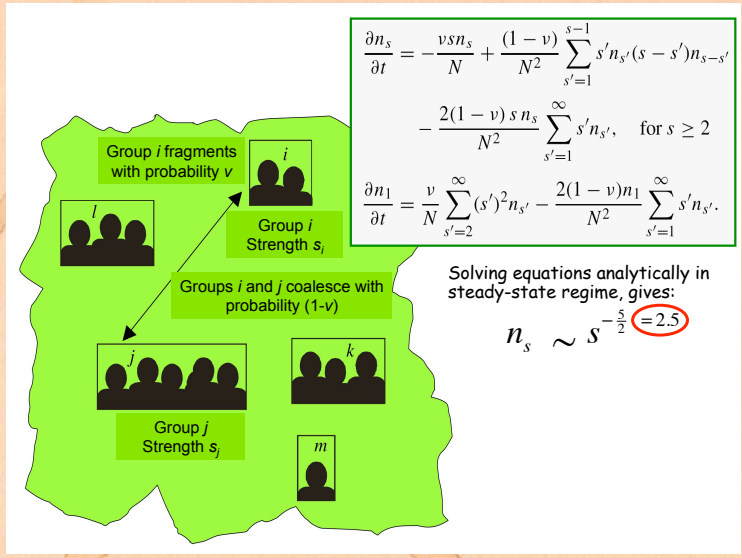

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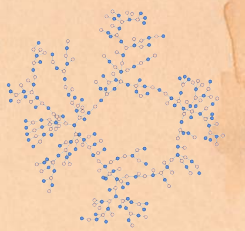
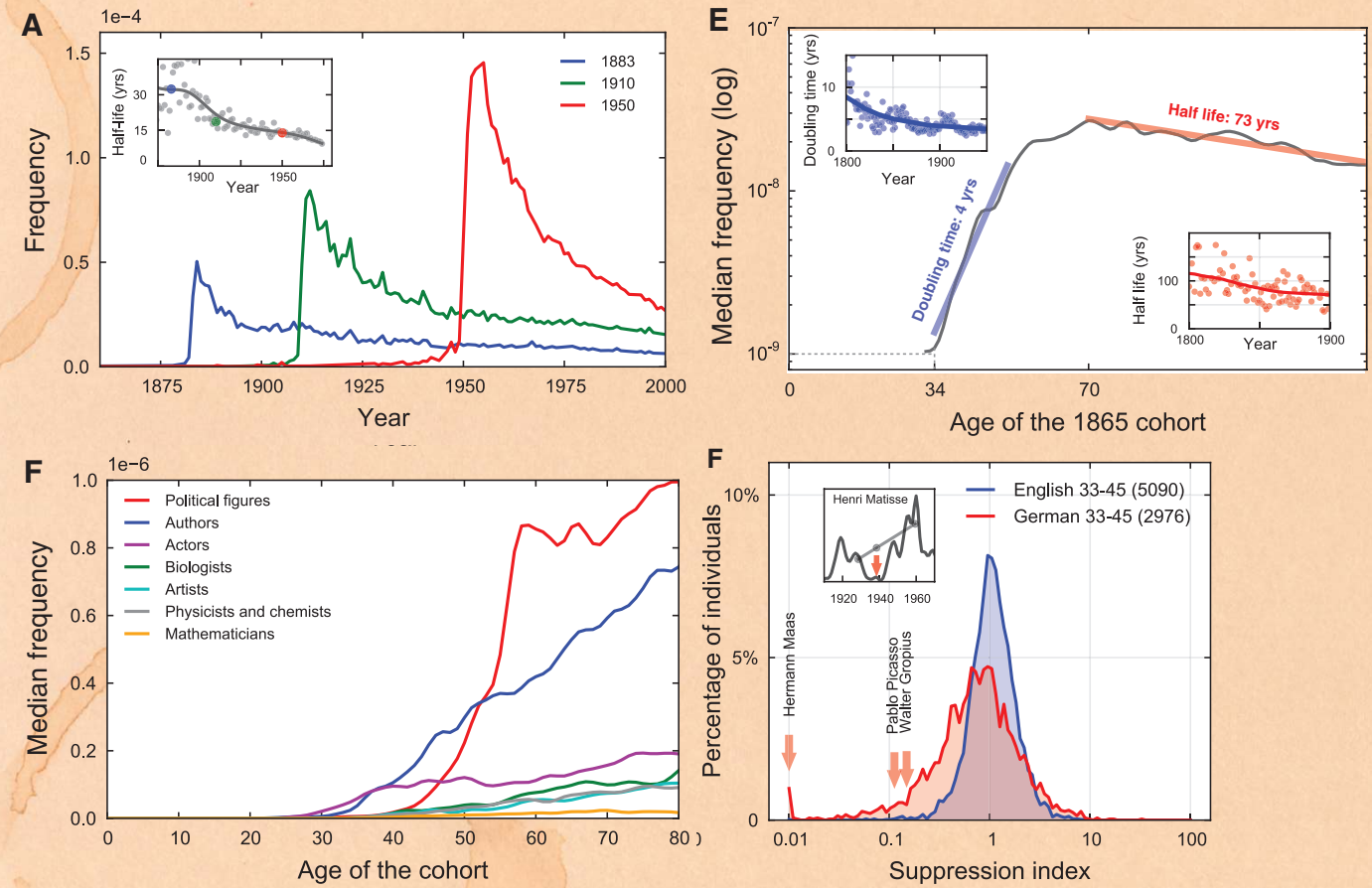


Culturomics—explore ‘book networks’

“Quantitative analysis of culture using millions of digitized books” by Michel et al., Science, 2011 [18]



http://www.culturomics.org/ (⊞)

Google Books ngram viewer (⊞)

Study networks and creativity:

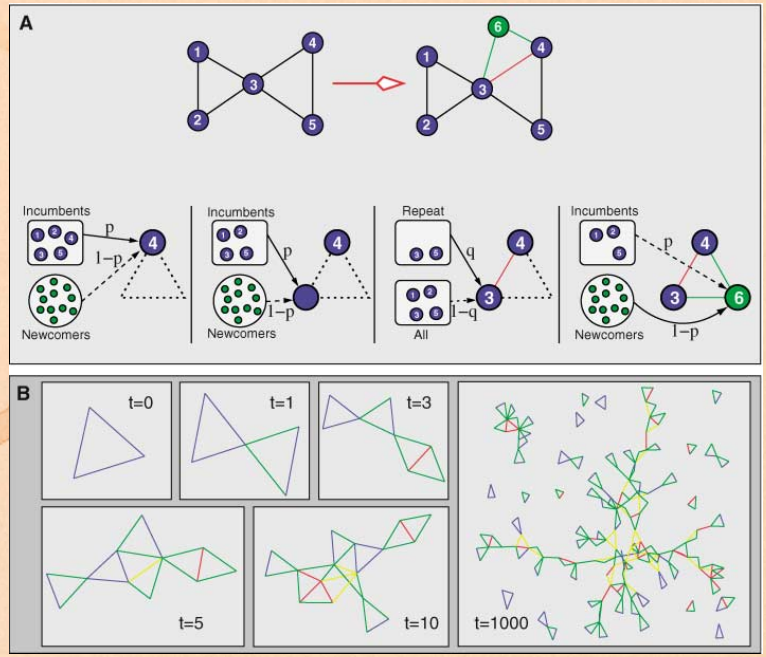
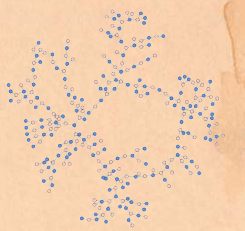


Fig. 2. Modeling the emergence of collaboration networks in creative enterprises. **(A)** Creation of a team with $m = 3$ agents. Consider, at time zero, a collaboration network comprising five agents, all incumbents (blue circles). Along with the incumbents, there is a large pool of newcomers (green circles) available to participate in new teams. Each agent in a team has a probability p of being drawn from the pool of incumbents and a probability $1 - p$ of being drawn from the pool of newcomers. For the second and subsequent agents selected from the incumbents' pool: (i) with probability q, the new agent is randomly selected from among the set of collaborators of a randomly selected incumbent already in the team; (ii) otherwise, he or she is selected at random among all incumbents in the network. For concreteness, let us assume that incumbent 4 is selected as the first agent in the new team (leftmost box). Let us also assume that the second agent is an incumbent, too (center-left box). In this example, the second agent is a past collaborator of agent 4, specifically agent 3 (center-right box). Lastly, the third agent is selected from the pool of newcomers; this agent becomes incumbent 6 (rightmost box). In these boxes and in the following panels and figures, blue lines indicate newcomer-newcomer collaborations, green lines indicate newcomer-incumbent collaborations, yellow lines indicate new incumbent-incumbent collaborations, and red lines indicate repeat collaborations. **(B)** Time evolution of the network of collaborations according to the model for $p = 0.5$, $q = 0.5$, and $m = 3$.

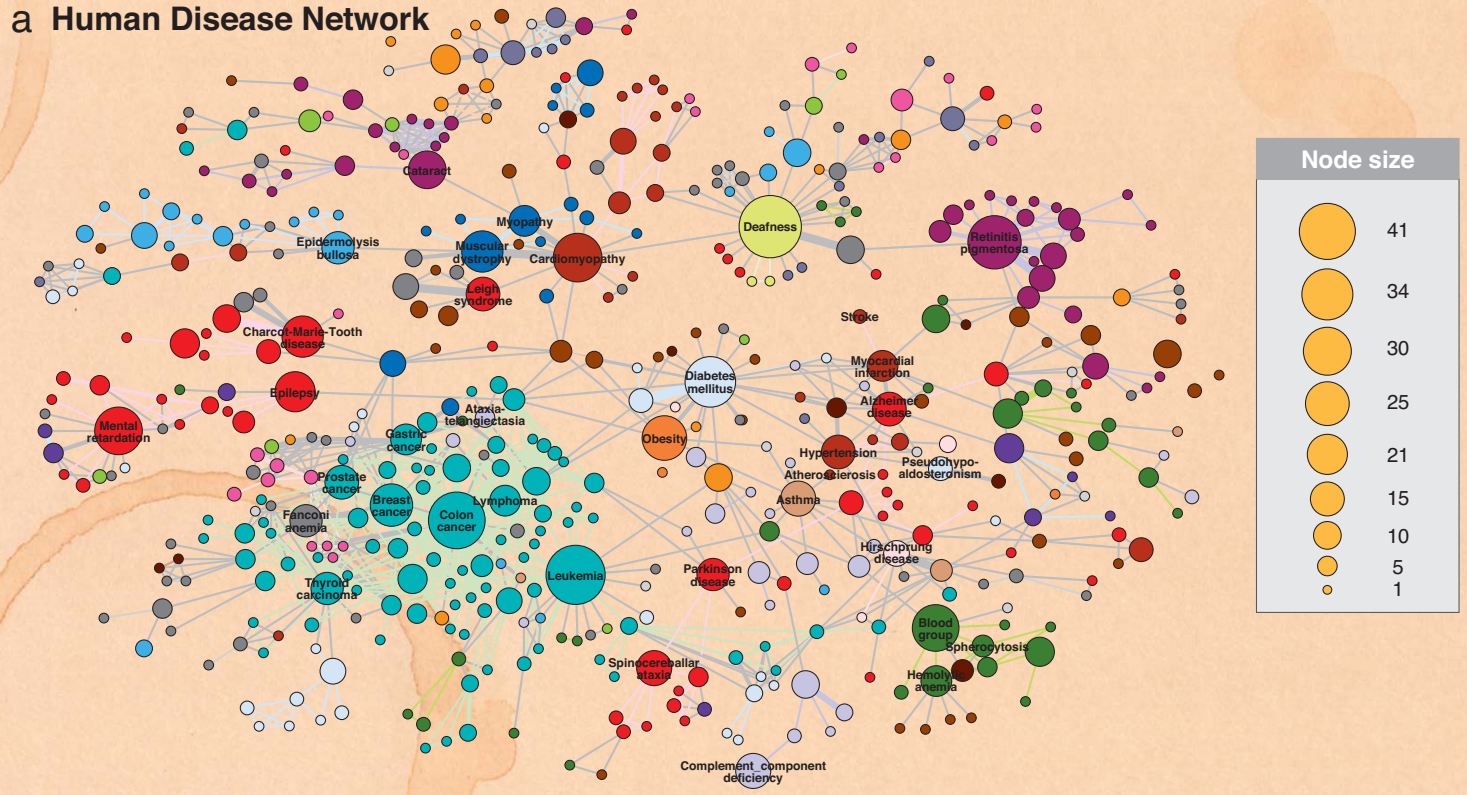
- Guimerà et al., Science 2005: [12] "Team Assembly Mechanisms Determine Collaboration Network Structure and Team Performance"
- Broadway musical industry
- Scientific collaboration in Social Psychology, Economics, Ecology, and Astronomy.

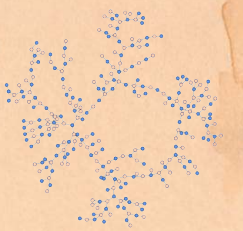


The UNIVERSITY of VERMONT

topics

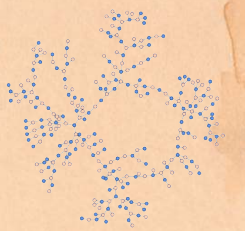
- Study the human disease and disease gene networks (Goh *et al.*, 2007):





topics

- Study collective tagging (or folksonomy)
- e.g., del.icio.us, flickr
- See work by Bernardo Huberman et al. at HP labs.



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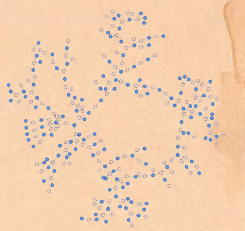

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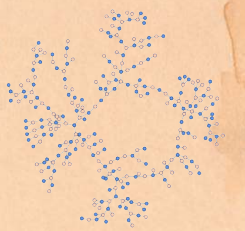
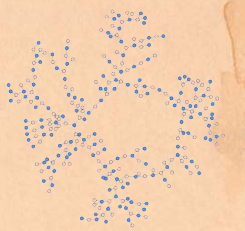


topics

- Study games (as in game theory) on networks.
- For cooperation: Review Martin Nowak's recent piece in Science: "Five rules for the evolution of cooperation." [19]
- Much work to explore: voter models, contagion-type models, etc.



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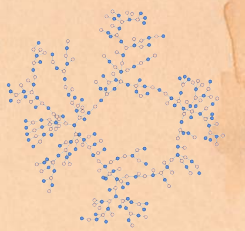

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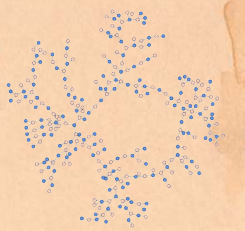

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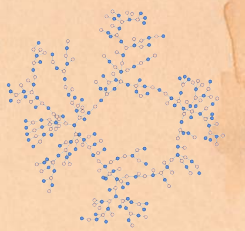
- Semantic networks: explore word-word connection networks generated by linking semantically related words.
- More general: Explore language evolution
- One paper to start with: "The small world of human language" by Ferrer i Cancho and Solé [9]
- Related: Study spreading of neologisms.



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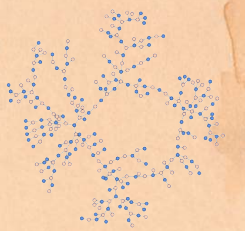

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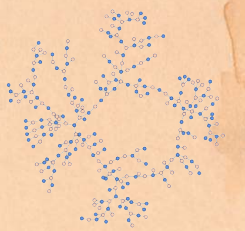

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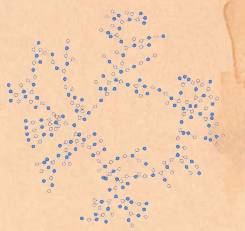
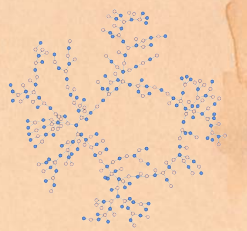


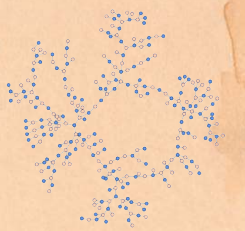
topics:

- Study social networks as revealed by email patterns, Facebook connections, tweets, etc.
- “Empirical analysis of evolving social networks” Kossinets and Watts, Science, Vol 311, 88-90, 2006. [17]
- “Inferring friendship network structure by using mobile phone data” Eagle, et al., PNAS, 2009.
- “Community Structure in Online Collegiate Social Networks”
  Traud et al., 2008.
  http://arxiv.org/abs/0809.0690 (⊞)



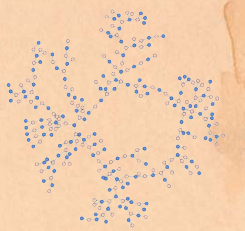
topics

- Study Stuart Kauffman's *nk* boolean networks which model regulatory gene networks [15]



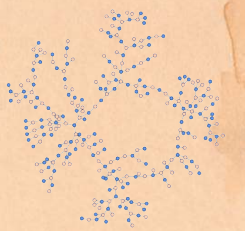
topics

- Explore work by Doyle, Alderson, et al. as well as Pastor-Satorras et al. on the structure of the Internet(s).



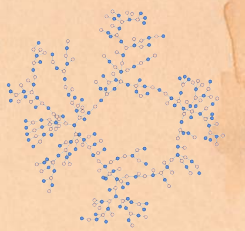
topics

- Review: Study work on massive multiplayer online games. How do social networks form in these games? [5]



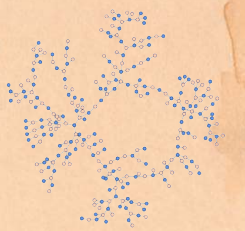
topics

- Study scientific collaboration networks.
- Mounds of data + good models.
- See seminal work by De Solla Price [20] plus modern work by Redner, Newman, *et al.*



topics

- Study Kearns et al.'s experimental studies of people solving classical graph theory problems [16]
- "An Experimental Study of the Coloring Problem on Human Subject Networks"
- (Possibly) Run some of these experiments for our class.



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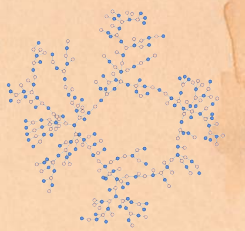
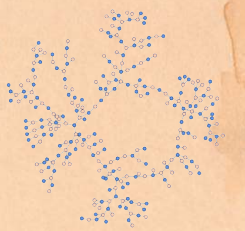


topics

- Vague/Large:
  Study amazon's recommender networks.
- See work by Sornette et al., Huberman et al.

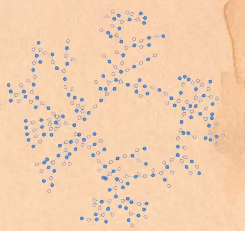
topics

- Vague/Large:
  Study network evolution of the Wikipedia's content.



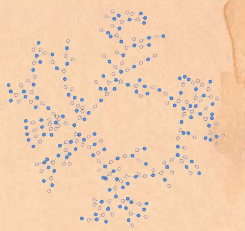
topics

- Vague/Large: How is the media connected? Who copies whom?
- Possibly use NY Times API.
- `http://memetracker.org/`
- Problem: Need to be able to measure interactions.



topics

- Vague/Large:
  Anything interesting to do with large-scale networks in evolution, biology, ethics, religion, history, influence, food, international relations, . . .
- Data is key.



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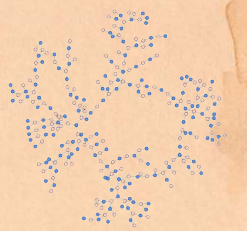

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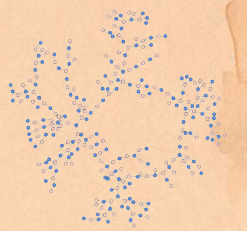

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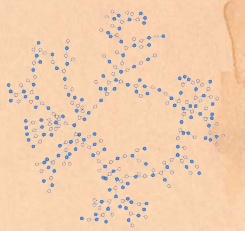

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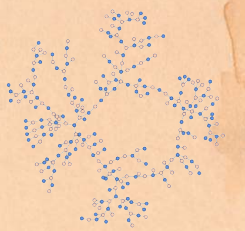

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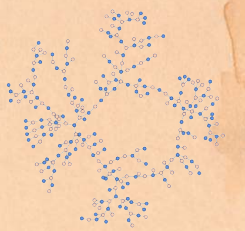

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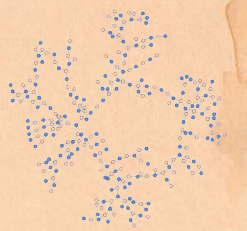

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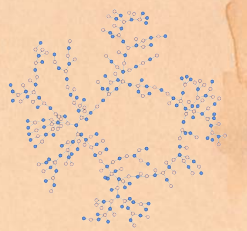

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