

# Semester projects

## Complex Networks

### CSYS/MATH 303, Spring, 2011

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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,
- ▶ ...

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## Outline

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## 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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## Semester projects

### Requirements:

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

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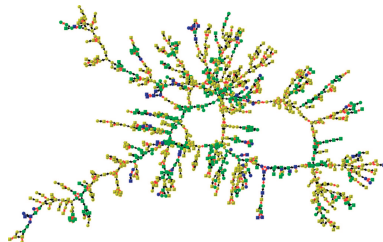
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## topics

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



- ▶ Obesity<sup>[6]</sup>
- ▶ Smoking cessation<sup>[7]</sup>
- ▶ Happiness<sup>[10]</sup>
- ▶ Loneliness<sup>[4]</sup>

Figure 4. Loneliness clusters in the Framingham Social Network. This graph shows the largest component of friends, spouses, and siblings at Fram 7 (created on the year 2000). There are 1039 individuals shown. Each node represents a participant, and its shape denotes gender (circles are female, squares are male). Lines between nodes indicate relationships used for defining blocks for friends and spouses. Node color denotes the mean number of days the first participant and all directly connected (Distance 1) linked participants felt lonely in the past week, with yellow being 0-1 days, green being 2-5, and blue being greater than 6 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 next text.

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

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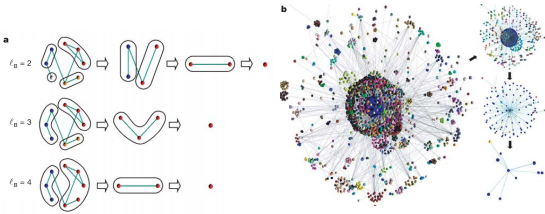
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topics

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



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topics:

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

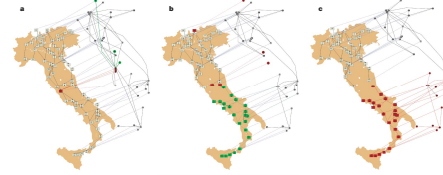


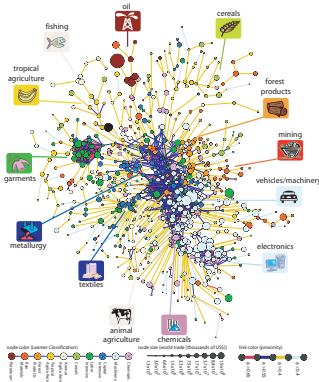
Figure 1: Modeling a blackout in Italy. Illustration of an iterative process of a cascade of failures using real-world data from a power network (based on the map of Italy) and an Internet network (sketch above the map) that were subjected to an electrical blackout that occurred in Italy in September 2003. 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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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?

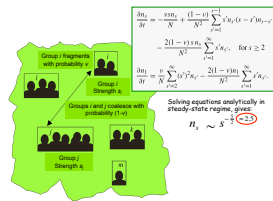


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topics

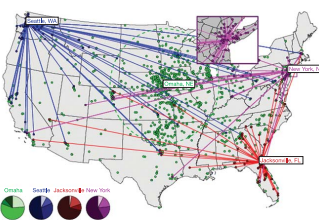
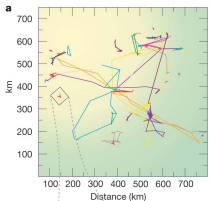
- ▶ Physics/Society—Wars: Study work that started with Lewis Richardson's “Variation of the frequency of fatal quarrels with magnitude” in 1949.
- ▶ Specifically explore Clauset *et al.* and Johnson *et al.*'s work [8, 14, 1] on terrorist attacks and civil wars



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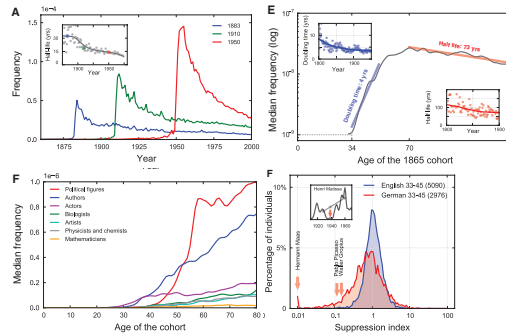
- ▶ Study movement and interactions of people.
- ▶ Brockmann *et al.* [2] “Where's George” study.
- ▶ Barabasi's group: tracking movement via cell phones [11].

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Culturomics—explore ‘book networks’

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

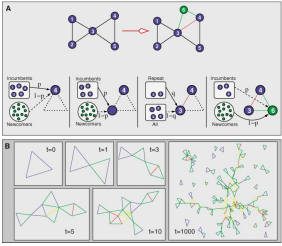


<http://www.culturomics.org/> (田)  
Google Books ngram viewer (田)

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## Study networks and creativity:



- ▶ 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.

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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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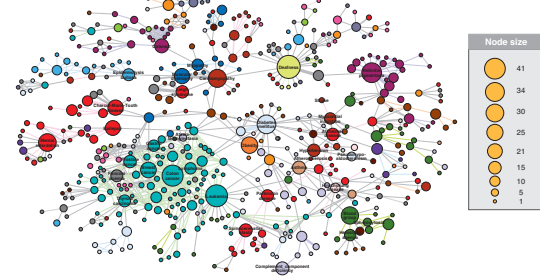


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## topics

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

a Human Disease Network



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## topics

- ▶ **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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## 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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## 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> (田)

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## topics

- ▶ Study Stuart Kauffman's *nk* boolean networks which model regulatory gene networks<sup>[15]</sup>

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## topics

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

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## topics

- ▶ **Review:** Study work on massive multiplayer online games. How do social networks form in these games?<sup>[5]</sup>

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## topics

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

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## topics

- ▶ Study Kearns et al.'s experimental studies of people solving classical graph theory problems<sup>[16]</sup>
- ▶ "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.

### Customers Who Bought This Item Also Bought

Product	Reviews	Price
Harry Potter Schoolbooks, Fantastic Beasts and... by J.K. Rowling	465	\$10.19
The Tales of Beedle the Bard, Collector's Edition by J.K. Rowling	153	
Harry, A History... The True Story of a Boy Wizard... by Melissa Anelli	52	\$10.88
Inkdeath (Uncharted) by Cornelia Funke	41	\$16.49

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## topics

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



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## References I

- [1] J. C. Bohorquez, S. Gourley, A. R. Dixon, M. Spagat, and N. F. Johnson.  
Common ecology quantifies human insurgency.  
[Nature](#), 462:911–914, 2009. pdf (田)
- [2] D. Brockmann, L. Hufnagel, and T. Geisel.  
The scaling laws of human travel.  
[Nature](#), pages 462–465, 2006. pdf (田)
- [3] S. V. Buldyrev, R. Parshani, G. Paul, H. E. Stanley, and S. Havlin.  
Catastrophic cascade of failures in interdependent networks.  
[Nature](#), 464:1025–1028, 2010. pdf (田)

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## 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.

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## References II

- [4] J. T. Cacioppo, J. H. Fowler, and N. A. Christakis.  
Alone in the crowd: The structure and spread of loneliness in a large social network.  
[Journal of Personality and Social Psychology](#), 97:977–991, 2009. pdf (田)
- [5] E. Castronova.  
Synthetic Worlds: The Business and Culture of Online Games.  
University of Chicago Press, Chicago, IL, 2005.
- [6] N. A. Christakis and J. H. Fowler.  
The spread of obesity in a large social network over 32 years.  
[New England Journal of Medicine](#), 357:370–379, 2007. pdf (田)

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## 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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## References III

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The collective dynamics of smoking in a large social network.  
[New England Journal of Medicine](#), 358:2249–2258, 2008. pdf (田)
- [8] A. Clauset, M. Young, and K. S. Gleditsch.  
On the Frequency of Severe Terrorist Events.  
[Journal of Conflict Resolution](#), 51(1):58–87, 2007. pdf (田)
- [9] R. Ferrer i Cancho and R. Solé.  
The small world of human language.  
[Proc. R. Soc. Lond. B](#), 26:2261–2265, 2001. pdf (田)

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## References IV

- [10] J. H. Fowler and N. A. Christakis.  
Dynamic spread of happiness in a large social network: longitudinal analysis over 20 years in the Framingham Heart Study.  
[BMJ](#), 337:article #2338, 2008. [pdf](#) (田)
- [11] M. C. González, C. A. Hidalgo, and A.-L. Barabási.  
Understanding individual human mobility patterns.  
[Nature](#), 453:779–782, 2008. [pdf](#) (田)
- [12] R. Guimerà, B. Uzzi, J. Spiro, and L. A. N. Amaral.  
Team assembly mechanisms determine collaboration network structure and team performance.  
[Science](#), 308:697–702, 2005. [pdf](#) (田)

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## References V

- [13] C. A. Hidalgo, B. Klinger, A.-L. Barabási, and R. Hausman.  
The product space conditions the development of nations.  
[Science](#), 317:482–487, 2007. [pdf](#) (田)
- [14] N. F. Johnson, M. Spagat, J. A. Restrepo, O. Becerra, J. C. Bohorquez, N. Suarez, E. M. Restrepo, and R. Zarama.  
Universal patterns underlying ongoing wars and terrorism, 2006. [pdf](#) (田)
- [15] S. Kauffman.  
[The Origins of Order](#).  
Oxford, 1993.

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## References VI

- [16] M. Kearns, S. Suri, and N. Montfort.  
An experimental study of the coloring problem on human subject networks.  
[Science](#), 313:824–827, 2006. [pdf](#) (田)
- [17] G. Kossinets and D. J. Watts.  
Empirical analysis of evolving social networks.  
[Science](#), 311:88–90, 2006. [pdf](#) (田)
- [18] J.-B. Michel, Y. K. Shen, A. P. Aiden, A. Veres, M. K. Gray, The Google Books Team, J. P. Pickett, D. Hoiberg, D. Clancy, P. Norvig, J. Orwant, S. Pinker, M. A. Nowak, and E. L. Aiden.  
Quantitative analysis of culture using millions of digitized books.  
[Science Magazine](#), 331:176–182, 2011. [pdf](#) (田)

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- [19] M. A. Nowak.  
Five rules for the evolution of cooperation.  
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- [20] D. J. d. S. Price.  
Networks of scientific papers.  
[Science](#), 149:510–515, 1965. [pdf](#) (田)
- [21] C. Song, S. Havlin, and H. A. Makse.  
Self-similarity of complex networks.  
[Nature](#), 433:392–395, 2005. [pdf](#) (田)
- [22] C. Song, S. Havlin, and H. A. Makse.  
Origins of fractality in the growth of complex networks.  
[Nature Physics](#), 2:275–281, 2006. [pdf](#) (田)

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Romanesque networks.  
[Nature](#), 433:365–366, 2005. [pdf](#) (田)

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