

# Research Methods for Social Network Analysis

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Sociology 526

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“A collection of human beings does not become a society because each of them has an objectively determined or subjectively impelling life-content. It becomes a society only when the vitality of these contents attains the form of reciprocal influence; only when one individual has an effect, immediate or mediate, upon another, is mere spatial aggregation or temporal succession transformed into society. If, therefore, there is to be a science whose subject matter is society and nothing else, it must exclusively investigate these interactions, these kinds and forms of sociation.”

–Georg Simmel, “The Problem of Sociology” (1908)

## What the course does not cover

Many topics are not treated in this course. If you came looking for a particular topic, look through the reading list to check whether it’s covered (or ask me). A copy of this reading list may be found on our course web page.

## Course Description

Whereas much sociology is focused on the analysis of *variables* (such as education and income) abstracted from observable relations among individuals and institutions, social network analysis is the study of structures of social relations. This seminar treats methods for social network research, emphasizing a “how-to” approach to analyzing existing datasets or those collected by seminar participants in their own research.

## Prerequisites

There are no formal prerequisites. As Degenne and Forsé (1999) write<sup>1</sup> (p. 12), “in some studies methodology goes straight to the Appendix, but not in network analysis. Most network analysts put methods at the heart of the analysis.” *Of course* I do not assume that you know about semigroup algebras, eigenvectors, or geodesic distances. My job is to get you comfortable with concepts such as these, by making them as concrete and research-relevant as possible. I am confident I can do this, but the “prerequisite” is motivation on your part to be interested in the practicalities of network analysis and its possible relevance to your research interests. This is a methods course with an attitude (see, e.g., the quotation above). It will help greatly if you have read widely in your (social) scientific fields of interest, have conducted your own research or thought about doing so, and have some basic computer and internet skills.

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<sup>1</sup> Introducing Social Networks ([1994] 1999), by Alain Degenne and Michel Forsé (London, Sage).

Computer programs: In order to learn how to run and use computer programs for network analysis, I will introduce you to the most widely known program for doing network analysis (UCINET) as well as to another network-analysis program with some distinctive features (PAJEK) and to a programming environment (R) that houses some of the most recent advances (and in which I have written many of my own programs that will be made available to you in this seminar). All the programs (and the R environment) may be downloaded from the course web page, and I ask you either to download them to your own computer if possible. Please read the small print in this footnote, including the note to Mac users.<sup>2</sup>

This course will not “work” for you unless you play around with all the programs, and unless you do some of this “playing” after almost every class (beginning with class 4; see the reading list). The TA in this class is me, and I aim to be available for your questions and concerns (including those about getting programs to run properly) after every class meeting.

Books to purchase: We’ll make extensive use of the Wasserman and Faust text, *Social Network Analysis, Methods and Applications* (Cambridge Univ. Press 1994). I think you should purchase it. In addition, I think you should purchase the **2011 (second ed., revised and expanded)** text by Wouter de Nooy, Andrej Mrvar, and Vladimir Batagelj, *Exploratory Social Network Analysis with Pajek*. (Cambridge Univ. Press). Read the footnote.<sup>3</sup> The other books ordered for this course at the bookstore are all great, but I don’t think you “need” to buy them; it’s up to you. The vast majority of other readings are available on the course web site. Take a look!

Other books: There is an explosion of new books on social network analysis. You do not need to purchase any of these (and **several of them are available free-of-charge** on the internet to UA students; **see the D2L page for links**); on the other hand, some seminar participants might wish to acquire /consult some of them. For those interested, I try to insert keys in the reading list to some relevant sections of these books.

Stephen P. Borgatti, Martin G. Everett, & Jeffrey C. Johnson 2013, *Analyzing Social Networks* (Sage, 296 pp). The book’s website has data and some helpful UCINET tutorials; however, see the footnote.<sup>4</sup>

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<sup>2</sup> PAJEK and the R computing environment are entirely free of charge. UCINET is free for 90 days and then requires a one-time \$40 fee for students—I think it’s well worth it.

Note to Mac users: R is available for PC, Mac, and Unix platforms. UCINET and PAJEK are inherently PC (Windows systems) programs. If you have a Mac, you can of course run PC programs by spending a lot of money on an emulator like VMware or Parallels. There is, however, an entirely free way to run PC programs on a Mac that may work for Mac users. This free solution involves the open-source programs *Wine* and *Wine Bottler*. Instructions for The D2L course page has detailed instructions (on the Main Menu page, where downloading UCINET and *Pajek* are given). If you are a Mac user and concerned whether you can run UCINET and *Pajek*, I suggest that you try to download these programs as soon as possible. Depending on your success at downloading the programs, you may want to rethink whether you will stay in the class. I would be glad to consult with you on the downloading questions.

<sup>3</sup> Concerning the *Pajek* book, please note that its Kindle version may not be usable. This is because the notes in the page margins of the book are essential for using it, and these marginal notes may not exist in the Kindle version.

<sup>4</sup> A review at Amazon.com says, “This book covers all the basic approaches [...] I was surprised, though, that there

David Easley & Jon Kleinberg 2010, *Networks, Crowds, and Markets: Reasoning about an Interconnected World* (Cambridge Univ. Press). → The authors are an economist and a computer scientist. Good news: The full-text of the book is **available online for free** (though the pagination differs slightly from the published version).

Eric D. Kolaczyk & Gábor Csárdi 2014, *Statistical Analysis of Network Data with R* (Springer; 207 pp). → Extremely helpful for people who want to do intermediate- or advanced-level network analysis using R packages such as igraph and statnet. Good news: The full-text of the book is **available online for free**.

Jenine K. Harris 2014, *An Introduction to Exponential Random Graph Modeling* (Sage “little green book,” Quantitative Methods in the Social Sciences series). → This is a really excellent introduction to an important though complex family of models. Good news: The full-text of the book is **available online for free**, as is an online appendix of all the R commands.

Silvia Domínguez and Betina Hollstein (eds.) 2014. *Mixed Methods Social Network Research: Design and Applications* (Cambridge Univ. Press). → How to intertwine qualitative and quantitative social network research methods.

Sean F. Everton 2012. *Disrupting Dark Networks* (Cambridge Univ. Press). → The author, a sociologist on the faculty at the Naval Postgraduate School, focuses on how social network analysis can be used to craft strategies to track, destabilize, and disrupt covert and illegal networks. Methodologically the book is very much in the style of de Nooy et al. (see above), featuring a “how-to-run-the-programs-by-clicking-where” approach to the UCINET and Pajek software (which we will be using) and also ORA (another highly useful suite of network analysis programs), with an applied-problem orientation. The running example (with open-source data supplied on the author’s website) is network analysis of a covert group believed to be behind several major bombings in Indonesia, 2003-09. The book’s website has all the data.

M.E.J. Newman 2010. *Networks, An Introduction* (Oxford Univ. Press; 772 pages). → This is by far the most mathematical-technical of the books listed here, yet presents material in an elegantly simple way with great intuition. The author is a physicist / complexity theorist.

Course web page: I will make extensive use of a course web site, D2L, sponsored by the University of Arizona. **You will find it helpful to “click” often on this site, probably doing so before every class meeting!** The web address (url) is:

<http://d2l.arizona.edu/>

Please “bookmark” this location on your home computer, for easy future reference. Once at the above location, use the “NetID Login” option. If you have enrolled in the course, you should be recognized. (Otherwise, see me.)

## Requirements

1. Full participation in a seminar of this type is desirable, and needs to be based on thorough preparation for each class. (*Read* the material and *think* about it before each class. Please note that *the reading list is not as long as it seems*—see the Note at the top of p. 5). Some of the readings are super-technical, so—not uncommonly—you won’t completely understand some readings. My goal however is to enable you to understand, criticize, and apply the major approaches we’ll be learning – through a combination of readings, class lectures, class discussion, handouts, using computer programs, and focusing on examples.

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wasn't much in-depth explanation of UCINET, the authors' own network analysis package....”

In addition to in-class participation, I am also asking everybody to participate at least once a week, on the “Discussions” page of our D2L web site. I will *not* in general be posing specific discussion questions. I will expect you to write each week something on the order of a page (200 – 250 words, just as a rough guide) concerning *either* the readings we have done during the past week or will be reading during the subsequent week, *or* an idea about how something we read might be used by you given your own Master’s thesis / doctoral dissertation / or other research interests. I would like you to post your comments to the whole class, to read each others’ posts, and to comment on them *with respect and support*. This will help us to come to class “in the middle of a discussion,” rather than “cold.” Participation: 30% of final seminar grade.

2. I will often assign homework, and occasionally collect it. All homework is **ungraded**. These assignments will usually involve repeating some analysis that we read about. The aim is to empower you as a network researcher who can conduct analyses and understand what you’re doing. Simply completing the homework will count in determining your final grade (20%). See again the second paragraph on page 2 above.
3. There will be some sort of midterm exercise. I might, *e.g.*, give you a published article and the network data on which it is based, and ask you to discuss/criticize/extend the author’s analysis by means of playing around with the same data, by using the programs we will have discussed in class. This is an *exercise*, not a magnum opus. (20%)
4. A final paper. You are very welcome to work on this by yourself, or with people from your own department, but **I especially encourage projects by groups of people who introduce themselves to other class members who come from different departments than their own, and who work together on an emergent piece of joint research**. In any event, the final paper will probably take one of four forms. Probably the most common form will be a data analysis paper, either analysis of data you’ve collected or a re-analysis of data made available through the course. But three other forms are also possible for the final paper: a research proposal; a conventional library-research term paper (“Social Network Imagery in the Novels of Balzac” and “Sustainability: The Contribution of Social Networks Research” are two among a very wide set of possible topics), or a critical essay (“What’s Wrong with Network Analysis” or “Bringing Together Social Networks, Rational Choice, Ethnomethodology, and Marxist Post-Structuralism” are possibilities). The paper will be due one week after the last class meeting. *Please talk with me as the semester goes along about your ideas for the paper, outlines, and your progress in writing the paper.* 30% of final course grade.

## Reading List

**Please note:** (1) Titles abbreviated on the reading list are given in full on pp. 2-3 above. (2) I do not assume that we will read all items listed under each class. Some items are listed for the sake of (increased) completeness, or for participants who have special interests in certain topics. It should be clear ahead of time, class by class, which specific readings I assume you will do for the following class. (2) We may spend more than one class on a few of these topics, and we won't get to all of them. (3) Many, in fact the vast majority, of the course readings (other than those in the Wasserman-Faust and de Nooy *et al.* textbooks, which I encourage you to purchase) are available on the D2L course web site.

### PART 1. The Discovery of Social Networks

#### 1. How do people acquire or construct useful information?

**Pp. 1-5** [= pp. 3-8 of the PDF] of Jenine K. Harris, *An Introduction to Exponential Random Graph Modeling* (Sage, 2014).

De Soto, Clifford B. 1960. "Learning a Social Structure." *Journal of Abnormal and Social Psychology* 60 (3):417-421.

Moody, James. 2006. "Fighting a Hydra: A Note on the Network Embeddedness of the War on Terror." *Structure and Dynamics: EJournal of Anthropological and Related Sciences* 1 (2):Article 9.

Franco Moretti, 2013. "Network Theory, Plot Analysis," *New Left Review* March-April 2011 (reprinted in Moretti, *Distant Reading*, London, Verso, pp. 211-240).

#### 2. When can your "weak" connections to other people be "strong"?

Granovetter, Mark S. 1973. "The Strength of Weak Ties." *The American Journal of Sociology* 78 (6):1360-1380.

**Pp. 18-20 and 25-30** in Burt, Ronald S. 1992. *Structural Holes: The Social Structure of Competition*. Cambridge, Mass.: Harvard University Press.

Onnela, J.-P., et al. 2007. "Structure and Tie Strengths in Mobile Communication Networks." *Proceedings of the National Academy of Sciences* 104 (18):7332-36.

*Other books* (optional): Easley & Kleinberg, *Networks, Crowds, Markets*, Sects. 3.1 to 3.5 (esp. Sects. 3.1, 3.2, and 3.5 on strong and weak ties and on structural holes and social capital)

#### 3. Social network research pragmatics: Data collection, measurement, design

Peter V. Marsden, "Recent developments in network measurement," ch. 2 (pp. 8-30) in Carrington, Peter J., John Scott, and Stanley Wasserman. 2005. *Models and Methods in Social Network Analysis*. New York: Cambridge University Press.

Marsden, Peter V. 1990. "Network Data and Measurement." *Annual Review of Sociology* 16 (1):435-463.

**Pp. 507-10** in R.L. Breiger, "Social Network Analysis," in Hardy, Melissa A., and Alan Bryman. 2004 [paperback 2009]. *Handbook of Data Analysis*. London: Sage.

*Optional:* Pp. **175-85** of Mario Diani, "Network Analysis," in Klandermans, Bert, and Suzanne Staggenborg. 2002. *Methods of Social Movement Research*. University of Minnesota Press.

*Optional:* Paragraphs 3-20 to 3-35 and App. B-29 to B-56 in US Army/Marine Corps counterinsurgency manual, *Counterinsurgency* (FM 3-24 / MCWP 3-33.5, December 2006).

*Optional:* Pp. **51-62** in Hardt, Michael, and Antonio Negri. 2004. *Multitude : War and Democracy in the Age of Empire*. New York: The Penguin Press, section on "Asymmetry and Full-Spectrum Dominance."

*Optional:* Pp. **39-43** in Melo, Alberto. 2004. "Local Citizen Action as a Form of Resistance Against the New Wave of Worldwide Colonization: The Case of the in Loco Association in Southern Portugal." *South European Society and Politics* 9 (2):16-45.

*Other books* (optional): Borgatti et al., *Analyzing*, ch. 3 ("Research Design"), ch. 4 ("Data Collection"); Everton, *Disrupting*, ch. 4 ("Gathering, Recording, and Manipulating Social Networks"); Newman, *Networks, An Intro*, pp. 1-104 [technological networks, social networks, information networks, biological networks]. Domínguez and Hollstein, *Mixed Methods Social Networks Research*, is relevant in its entirety.

#### 4. An introduction to computer programs: analysis of first data examples

[Data we will analyze:] Shih, Hsin-Yu. 2006. "Network Characteristics of Drive Tourism Destinations: An Application of Network Analysis in Tourism." *Tourism Management* 27 (5):1029-1039.

[Data we will analyze:] Adamic, Lada A., and Natalie Glance. 2005. "The Political Blogosphere and the 2004 U.S. Election: Divided they Blog." *Proceedings of the 3rd international workshop on Link discovery* (Link-KDD '05, ACM), 36-43.

[Data we will analyze:] Pp. **1265-68** in Padgett, John F., and Christopher K. Ansell . 1993. "Robust Action and the Rise of the Medici, 1400-1434." *The American Journal of Sociology* 98 (6):1259-1319.

de Nooy et al., *Pajek* (2<sup>nd</sup>. ed.), ch. 1, "Looking for Social Structure," pp. 3-33.

Wasserman & Faust, *Social Network Analysis*, pp. 59-66 ("Datasets found in these pages").

*Other books* [optional]: Everton, *Disrupting*, ch. 3 ("Getting Started with UCINET, NetDraw, Pajek, and ORA")

#### 5. Centrality and structure (and an introduction to the UCINET program)

Wasserman & Faust, *Social Network Analysis*, p. **110** (definition of "geodesic") and pp. **177-192** (on three types of centrality measure).

Pp. **1274-80** in Padgett, John F., and Christopher K. Ansell . 1993. "Robust Action and the Rise of the Medici, 1400-1434." *The American Journal of Sociology* 98 (6):1259-1319.

de Nooy et al., *Pajek* (2<sup>nd</sup>. ed.), pp. 141-52.

P. **477** and pp. **479-80** (Sects. 1 and 3-4) in Lusseau, David, and M. E. J. Newman. 2004. "Identifying the Role that Animals Play in their Social Networks." *Proceedings of the Royal Society of London. Series B: Biological Sciences* 271 (Suppl 6):S477-S481.

Katherine Giuffre, . 2001. "Mental Maps: Social Networks and the Language of Critical Reviews." *Sociological Inquiry* 71 (3):381-393.

*Optional*

Freeman, Linton C. . 1977. "A Set of Measures of Centrality Based on Betweenness." *Sociometry* 40 (1):35-41.

Beckfield, Jason. 2010. "The Social Structure of the World Polity." *The American Journal of Sociology* 115 (4):1018-1068.

Baker, Wayne E., and Robert R. Faulkner . 1993. "The Social Organization of Conspiracy: Illegal Networks in the Heavy Electrical Equipment Industry." *American Sociological Review* 58 (6):837-860.

*Other books* [optional]: Everton, *Disrupting*, ch. 7; Hennig, *Studying Social Networks*, 23-30; Newman, *Networks, An Intro*, 181-93 and 324-29.

## 6. Positive and negative eigenvector centrality: Different measures are needed for distinctive models of networks

Pp. 4-5 of Newman, M.E.J. . 2008. "Mathematics of Networks." in *The New Palgrave Dictionary of Economics Online*, edited by S.N. Durlauf, and L.E. Blume. Palgrave Macmillan.

Rosenthal, Naomi, et al . 1987. "Centrality Analysis for Historians." *Historical Methods* 20 (2):53-62.

Bonacich, Phillip . 1987. "Power and Centrality: A Family of Measures." *The American Journal of Sociology* 92 (5):1170-1182.

de Nooy et al., *Pajek* (2<sup>nd</sup>. ed.), 153-55.

### *How to Think about Centrality Measures for Social Network Analysis while You are Doing It:*

Roberts, Nancy, and Sean F. Everton. 2011. "Strategies for Combating Dark Networks." *Journal of Social Structure* 12 (2): 1-32. → esp. pp. 1-4, 7-8, 14, 20, 23-24.

Borgatti, Stephen P. 2005. "Centrality and Network Flow." *Social Networks* 27 (1):55-71.

*Optional:* Burris, Val . 1 April 2004. "The Academic Caste System: Prestige Hierarchies in PhD Exchange Networks." *American Sociological Review* 69 239-264.

*Other books* [optional]: Easley & Kleinberg, *Networks, Crowds, and Markets*, Sections 14.1 to 14.6; Newman, *Networks, In Intro*, 169-72.

## 7. An introduction to R for social network analysis

Butts, Carter T., et al. "Network Analysis with `statnet` for Individual, Organizational, and International Relations Applications." Handout, Duke Political Networks Conference, Durham, NC, May 2010. → Read Section 1 (pp. 3-6), Section 3 (pp. 9-13), and Section 2 (pp. 7-8) in that order.

Butts, Carter T. . 2007. "Social Network Analysis with `sna`." *Journal of Statistical Software* 24 (6):1-51.

*Optional introduction to the R igraph package:* Kolaczyk & Csárdi, *Statistical Analysis of Network Data with R*, ch. 2 ("Manipulating Network Data")

## 8. Structural Holes and Clustering Coefficients: Examples of local transitivity

[read Borgatti (below) first] Pp. **48-81** in Burt, Ronald S. 1992. *Structural Holes : The Social Structure of Competition* . Cambridge, Mass.: Harvard University Press.

Borgatti, Stephen P. 1997. "Structural Holes: Unpacking Burt's Redundancy Measures." *Connections* 20 (1): 35-38.

Esp. pp. **493-502** in Watts, Duncan J. 1999. "Networks, Dynamics, and the Small-World Phenomenon." *American Journal of Sociology* 105 (2):pp. 493-527.

Esp. pp. **407-08** [section on "Clustering"] in Newman, M. E. J. 2001. "The Structure of Scientific Collaboration Networks." *Proceedings of the National Academy of Sciences* 98 (2):404-409.

*How to think about brokerage and closure while you're analyzing it:*

Crossley, Nick. 2010. "The Social World of the Network. Combining Qualitative and Quantitative Elements in Social Network Analysis." *Sociologica* 2010 (1): online journal (<http://www.sociologica.mulino.it/>)

*Optional:* Krackhardt, David, 1999. "The Ties that Torture: Simmelian Tie Analysis in Organizations." *Research in the Sociology of Organizations* 16 183-210.

*Other books (optional):* Borgatti et al., *Analyzing*, pp. 274-76; Everton, *Disrupting*, ch. 8 ("Brokers, Bridges, and Structural Holes"), and 148-52 (clustering coef.); Newman, *Networks, An Intro*, 199-204 (clustering coefficient).

## 9. Visualization in UCINET and R

UCINET visualization with STATNET: Borgatti et al., *Analyzing Social Networks*, ch. 7, pp. 100-124. (Read it in conjunction with the specific commands given in the online companion to the book.)

Some R tutorials (using package sna) by Melissa Clarkson (<http://students.washington.edu/mclarkso/>):  
 gplot  
 plot.sociomatrix  
 gplot.layout

A tutorial for R package igraph by Dimitir Toshkov (blog *Rules of Reason: Uses and Abuses of Research in Public Policy and Administration*, <https://rulesofreason.wordpress.com/2012/11/05/network-visualization-in-r-with-the-igraph-package/>)

## 10. Social Networks on maps and geospatial layouts

I will be discussing an R implementation of an example in de Nooy et al, *Pajek*, 2<sup>nd</sup> ed. (Section 2.5, pp. 50-57, esp. Fig. 26): a geographical view of world trade in metal manufactures; take a look at those pages and the trade network superimposed on the world map. Also read:

Faust, Katherine, et al. 2000. "Spatial Arrangement of Social and Economic Networks among Villages in Nang Rong District, Thailand." *Social Networks*, 21 (4):311-337.

Hipp, John R., Robert W. Faris, and Adam Boessen. 2012. "Measuring 'Neighborhood': Constructing Network Neighborhoods." *Social Networks* 34 (1):128-140.



## 11. Outward-looking ties and resilience

Borck, Lewis, Barbara J. Mills, Matthew A. Peeples, and Jeffery J. Clark. 2015. "Are Social Networks Survival Networks? An Example from the Late Pre-Hispanic US Southwest." *Journal of Archaeological Method and Theory* 1-25.

Everett, Martin G., and Stephen P. Borgatti. 2012. "Categorical Attribute Based Centrality: E-I and G-F Centrality." *Social Networks* 34 (4):562-569.

Lusseau and Newman, "Identifying the Role..." [bottleneck dolphins paper, Class 5 above], Sect. 2, pp. S477-79.

*Optional:* Newman, Mark E. J. 2003. "Mixing Patterns in Networks." *Physical Review E* 67 (2):026126-1-026126-13.

*Also of interest (optional):* Watts, Jameson K. M., and Kenneth W. Koput. 2014. "Supple Networks: Preferential Attachment by Diversity in Nascent Social Graphs." *Network Science* 2 (3):303-325.

*Other books (optional):* Borgatti et al., *Analyzing*, pp. 273-74.

## 12. Cognitive Social Structure

Krackhardt, David. 1987. "Cognitive Social Structures." *Social Networks* 9 (2):109-134.

Muntanyola, Dafne. 2014. "How Multimodality Shapes Creative Choice in Dance." *Revista Internacional de Sociología* 72(3):563-582.

*Optional:* Siciliano, Michael D., Deniz Yenigun, and Gunes Ertan. 2012. "Estimating Network Structure Via Random Sampling: Cognitive Social Structures and the Adaptive Threshold Method." *Social Networks* 34 (4):585.

## **PART 2. Structural Equivalence, Blockmodels and Community Detection**

### 13. Positions in networks: an introduction

Michael, Judd H. 1997. "Labor Dispute Reconciliation in a Forest Products Manufacturing Facility." *Forest Products Journal* 47 (11/12):41-45. [First encountered in our "ethics" section, above.]

Moody, James, and Douglas R. White. 2003. "Structural Cohesion and Embeddedness: A Hierarchical Concept of Social Groups." *American Sociological Review* 68 (1):pp. 103-127.

Esp. pp. **81-89** in de Nooy et al., *Pajek* (2<sup>nd</sup>. ed.), ch. 3 ("Cohesive Subgroups")

Esp. pp. **161-172** in de Nooy et al., *Pajek* (2<sup>nd</sup> ed.), ch. 7 ("Brokers and Bridges")

*Other books (optional):* Borgatti et al., *Analyzing*, ch. 11 ("Subgroups").

### 14. Finding community structure via iterative correlations

Wasserman & Faust, *Social Network Analysis* text, on structural equivalence, pp. 354-93.

Chen, Chun-Houh . 2002. "Generalized Association Plots: Information Visualization Via Iteratively Generated Correlation Matrices." *Statistica Sinica* 12 (1):7-29. → In particular, read the Abstract and look at Fig. 1!

Luo, Wei, Peifeng Yin, Qian Di, et al. 2014. "A Geovisual Analytic Approach to Understanding Geo-Social Relationships in the International Trade Network." *PLOS One*. February 18, 2014. doi: 10.1371/journal.pone.0088666

Munene, Esther, S. Mottice, and J. Reid. 2013. "Evaluating a Social Network Analytic Tool to Support Outbreak Management and Contact Tracing in an Outbreak of Pertussis." *Online Journal of Public Health Informatics* 5 (1):e72.

Shiratori, Yuki, et al. 2014. "Network Analysis for Motives in Suicide Cases: A Cross-Sectional Study." *Psychiatry and Clinical Neurosciences* 68 (4):299-307.

Friendly, Michael . 2002. "Corrgrams: Exploratory Displays for Correlation Matrices." *The American Statistician* 56: 316-324.

*Optional:* Sharp, John M., Eui Hang Shin, and LeRoy F. Smith . 1982. "A Network Analysis of Departmental Prestige Based on Origins of Faculty Degrees." *Behavioral Science* 27 (1):12-25.

*Other books (optional):* Everton, *Disrupting*, 299-306.

## 15. Blockmodels of roles and positions

White, Harrison C., Scott A. Boorman, and Ronald L. Breiger . 1976. "Social Structure from Multiple Networks. I. Blockmodels of Roles and Positions." *American Journal of Sociology* 81 (4):730-780.

Pp. **510-14** in R.L. Breiger, "Social Network Analysis" (cited above, class 3).

Pp. **95-101** (Sect. 6.3, "Network Block Models") in Kolaczyk & Gábor Csárdi, *Statistical Analysis of Network Data with R*, 2014 (online book available through D2L page).

Esp. pp. **299-317** in de Nooy et al., *Pajek* (2<sup>nd</sup>. ed.), ch. 12 ("Blockmodels").

*Optional:* Wasserman & Faust on blockmodels, pp. 394-424. [Also pp. 679-88, on goodness of fit].

*Optional:*

*Other books (optional):* Everton, *Disrupting*, ch. 9; Borgatti et al., *Analyzing*, pp. 206-20.

## 16. Applications

*Read this one:*

Brockhaus, Maria, and Monica Di Gregorio. 2014. "National REDD+ Policy Networks: From Cooperation to Conflict." *Ecology and Society* 19 (4):1-16.

*... and read at least one of these:*

Pp. **41-53**, especially discussion of **Table 4.2**, in Leontief, Wassily W. [1966] 1986. *Input-Output Economics*. New York: Oxford University Press.

Especially pp. **1525-34** in Cunningham, David, Colleen Nugent, and Caitlin Slodden. 2010. "The Durability of Collective Memory: Reconciling the "Greensboro Massacre"." *Social Forces* 88 (4):1517-1542.

Radil, Steven M., Colin Flint, and George E. Tita. 2010. "Spatializing Social Networks: Using Social Network Analysis to Investigate Geographies of Gang Rivalry, Territoriality, and Violence in Los Angeles." *Annals of the Association of American Geographers* 100 (2):307-326.

Especially pp. **116-37** in Gerlach, Michael L. 1992. "The Japanese Corporate Network: A Blockmodel Analysis." *Administrative Science Quarterly* 37 (1):105-139.

#### *Optional*

Herman, Nancy J. 1984. "Conflict in the Church: A Social Network Analysis of an Anglican Congregation." *Journal for the Scientific Study of Religion* 23 (1):60-74.

Giuffre, Katherine. 1999. "Sandpiles of Opportunity: Success in the Art World." *Social Forces* 77 (3):815-832.

Anheier, Helmut K., Jurgen Gerhards, and Frank P. Romo. 1995. "Forms of Capital and Social Structure in Cultural Fields: Examining Bourdieu's Social Topography." *The American Journal of Sociology* 100 (4):859-903.

DiMaggio, P. 1986. "Structural Analysis of Organizational Fields: A Blockmodel Approach." Pp. 335-370 in *Research in Organizational Behavior*, edited by B.M. Staw, and L.L. Cummings. JAI Press.

### **17. Finding community structure via (a) eigenvectors and (b) link removal**

Newman, M. E. J. . 2006. "Modularity and Community Structure in Networks." *Proceedings of the National Academy of Sciences* 103 (23):8577-8582.

Newman, Mark E. J., and Michelle Girvan . 2004. "Finding and Evaluating Community Structure in Networks." *Physical Review E* 69 (026113):026113-1-026113-15.

#### *Optional*

Also of interest: Newman, M. E. J. . 2005. "A Measure of Betweenness Centrality Based on Random Walks." *Social Networks*, 27 (1):39-54.

Csardi, Gabor, and Tamas Nepusz . 2006. "The Igraph Software Package for Complex Network Research." *InterJournal, Complex Systems* 1695

*Other books (optional):* Newman, *Networks, An Intro*, ch. 11; Borgatti et al., *Analyzing*, pp. 195-97.

## **PART 3: Dualities**

### **18. Duality and affiliation networks**

*Read this one:*

Breiger, Ronald L. 1974. "The Duality of Persons and Groups." *Social Forces* 53 (2):181-190.

*... and read at least one of these:*

Diani, Mario, and Maria Kousis. 2014. "The Duality of Claims and Events: The Greek Campaign Against the Troika's Memoranda and Austerity, 2010-2012." *Mobilization: An International Quarterly* 19 (10):387-404.

Frost, Simon D. W. 2007. "Using Sexual Affiliation Networks to Describe the Sexual Structure of a Population." *Sexually Transmitted Infections* 83 (suppl\_1):i37-42.

Blaschke, Steffen, Dennis Schoeneborn, and David Seidl. 2012. "Organizations as Networks of Communication Episodes: Turning the Network Perspective Inside Out." *Organization Studies* 33 (7):879-906.

Wasserman & Faust, pp. 291-326.

Optional:

Georg Simmel, "How is Society Possible?" (pp. 6-22), "The Problem of Sociology" (pp. 23-35), and "Group Expansion and the Development of Individuality" (pp. 251-93) in Donald Levine (ed.), *Georg Simmel on Individuality and Social Forms* (University of Chicago Press, 1972).

Excerpts from Davis, Allison, et al. 1941. *Deep South; a Social Anthropological Study of Caste and Class*. Chicago, Ill.: University of Chicago Press.

*Other books* (optional): Easley & Klienberg, *Networks, Crowds, Markets*, Section 4.3; Everton, *Disrupting*, 102-07 and ch. 8.5; Borgatti et al., *Analyzing*, ch. 13 ("Analyzing Two-Mode Data").

## 19. Tripartite and multimode networks

Fararo, Thomas J., and Patrick Doreian . 1984. "Tripartite Structural Analysis: Generalizing the Breiger-Wilson Formalism." *Social Networks* 6 (2):141-175.

Cornwell, Benjamin, Timothy J. Curry, and Kent P. Schwirian . 2003. "Revisiting Norton Long's Ecology of Games: A Network Approach." *City and Community* 2 (2):121-142.

Carley, Kathleen M., "Dynamic Network Analysis," pp. 133-45 in Breiger, Ronald L., et al. 2003. *Dynamic Social Network Modeling and Analysis : Workshop Summary and Papers*. Washington, D.C.: National Research Council of the National Academies.

*Also of interest:* Norton E. Long . 1958. "The Local Community as an Ecology of Games." *The American Journal of Sociology* 64 (3):251-261.

*Optional:* Melamed, David, Ronald L. Breiger, and A. Joseph West. 2013. "Community Structure in Multi-Mode Networks: Applying an Eigenspectrum Approach." *Connections* 33 (1):18-23.

## 20. Ecologies of affiliation

McPherson, Miller . 1983. "An Ecology of Affiliation." *American Sociological Review* 48 (4):519-532.

Genkin, Michael, et al. [Matthew Brashears, PI], "Package Blaunet" [R manual, 2014]

*Optional:* "Feld, Scott L., and Bernard Grofman. 2009. "Homophily and the Focused Organization of Ties." Pp. 521-543 in *Oxford Handbook of Analytical Sociology*, edited by Peter Hedstrom and Peter Bearman. Oxford University Press.

*Optional:* Mark, Noah . 1998. "Birds of a Feather Sing Together." *Social Forces* 77 (2):453-485.

*Other books (optional):* Easley & Kleinberg, *Networks, Crowds, and Markets*, Sects. 4.1—4 .2, on homophily.

## **PART 4: Testing Hypotheses: Some Statistical Models for Networks**

### **21. Assessing Correlation and Regression Coefficients for Networks (Quadratic Assignment Procedure)**

Krackhardt, David. 1987. "QAP Partialing as a Test of Spuriousness." *Social Networks* 9 171-186.

Borgatti et al., *Analyzing Social Networks*, **pp. 125-138**.

Sects. 4.1 – 4.3 and 4.5-4.6 (pp. **14-16**) in Butts, Carter T., et al. "Network Analysis with statnet for Individual, Organizational, and International Relations Applications." Handout, Duke Political Networks Conference, Durham, NC, May 2010.

*Optional:* Dekker, David, David Krackhardt, and Tom A. B. Snijders. 2007. "Sensitivity of MRQAP Tests to Collinearity and Autocorrelation Conditions." *Psychometrika* 72 (4):563-581.

Other books (optional): Everton, *Disrupting*, 349-59 (multivariate regression for networks).

### **22. Stochastic blockmodels**

Wang, Yuchung J., and George Y. Wong . 1987. "Stochastic Blockmodels for Directed Graphs." *Journal of the American Statistical Association* 82 (397):8-19.

Wasserman & Faust, pp. 692-706.

*Optional:* Nowicki, Krzysztof, and Tom A. B. Snijders . 2001. "Estimation and Prediction for Stochastic Blockstructures." *Journal of the American Statistical Association* 96 (455):1077-1087.

### **23. ERGM (Exponential Random Graph) Models: A Bare Introduction (Class 1 of 2)**

*Please begin with this brief intuitive introduction:* Borgatti et al., *Analyzing Social Networks*, **pp. 139-145**.

Harris, Jenine K. 2014. *An Introduction to Exponential Random Graph Modeling* (Sage "little green book," full text is available online). **Pp. 33-54** of Chapter 3 ("Building a Useful ERGM").

**Commands 1-22** in Harris's "Online Appendix A: R Code" (available through the course website).

### **24. ERGM (Exponential Random Graph) Models: A Bare Introduction (Class 2 of 2)**

Harris 2014 (see above). **Pp. 55-90** of Chapter 3.

**Commands 23-46** in Harris's "Online Appendix A: R Code" (see previous class).

*Note:* For reference to certain terms in the model—GWD, GWESP, GWDSP (a.k.a. alternating  $k$ -stars, alternating  $k$ -triangles, alternating  $k$ -twopaths), see **pp. 25-31** in Ch. 2. [And **also see** the Borgatti *et al.* reference in the previous class.]

*Some optional references on ERGMs:*

*Optional book:* Lusher, Dean, Johan Koskinen, and Garry Robins, 2013. *Exponential Random Graph Models for Social Networks: Theory, Methods, and Applications*. Cambridge and New York: Cambridge University Press.

*Optional:* Goodreau, Steven M., et al. 2007. "A Statnet Tutorial." *Journal of Statistical Software* 24 (9):1-26.

*Optional:* Morris, Martina, Mark S. Handcock, and David R. Hunter. 2007. "Specification of Exponential-Family Random Graph Models: Terms and Computational Aspects." *Journal of Statistical Software* 24 (4):1-24.

*Optional [empirical study]:* Wimmer, Andreas, and Kevin Lewis. 2010. "Beyond and Below Racial Homophily: ERG Models of a Friendship Network Documented on Facebook." *American Journal of Sociology* 116 (2):583-642.

*Optional:* Robins, Garry, et al. 2007. "An Introduction to Exponential Random Graph ( $p^*$ ) Models for Social Networks." *Social Networks* 29 (2):173-191.

*Other books (optional):* Newman, *Networks, An Intro*, 565-85.

## **PART 5. Further topics (as time permits and as interests dictate)**

### **25. Some ethical issues**

Lazer, David, Alex Pentland, Lara Adamic, et al. 2009. "Computational Social Science." *Science* 323 721-723.

[read previously:] Michael, Judd H. 1997. "Labor Dispute Reconciliation in a Forest Products Manufacturing Facility." *Forest Products Journal* 47 (11/12):41-45.

Borgatti, Stephen P., and José-Luis Molina. 2005. "Toward Ethical Guidelines for Network Research in Organizations." *Social Networks* 27 (2):107-117.

Especially p. 341 and pp. 348-50, 355-58 in Solberg, Lauren B. 2012. "Regulating Human Subjects Research in the Information Age: Data Mining on Social Networking Sites." *Northern Kentucky Law Review* 39 (2):327-358.

Klov Dahl, Alden S. 2005. "Social Network Research and Human Subjects Protection: Towards More Effective Infectious Disease Control." *Social Networks* 27 (2):119-137.

*Optional* – However, please read several of the following (your choice, depending on your research interests):

Breiger, Ronald L. 2005. "Introduction to Special Issue: Ethical Dilemmas in Social Network Research." *Social Networks* 27 (2):89-93.

Goolsby, Rebecca. 2005. "Ethics and Defense Agency Funding: Some Considerations." *Social Networks* 27 (2):95-106.

Kadushin, Charles. 2005. "Who Benefits from Network Analysis: Ethics of Social Network Research." *Social Networks* 27 (2):139-153.

[Ethical Targeting?] Gjelten, Tom. 2010. "U.S. 'Connects the Dots' to Catch Roadside Bombers." *National Public Radio* broadcast December 3 (audio and transcription).

Everton, *Disrupting*, pp. 367-83, "Disrupting Dark Networks Justly."

## 26. Ego Networks

Borgatti et al., *Analyzing*, pp. 262-283.

## 27. Blockmodels from balance for two relations, and Generalized blockmodeling

Doreian, Patrick, and Andrej Mrvar . 2009. "Partitioning Signed Social Networks." *Social Networks* 31 (1):1-11.

Doreian, Patrick . 1999. "An Intuitive Introduction to Blockmodeling with Examples." *Bulletin de Méthodologie Sociologique* 61 (January): 5-34.

Esp. pp. 317-27 in de Nooy et al., *Pajek*, (2<sup>nd</sup> ed.), ch. 12.

*Optional:* Doreian, Patrick, Vladimir Batagelj, and Anuška Ferligoj. 2005. *Generalized Blockmodeling*. Cambridge, U.K. ; New York: Cambridge University Press.

*Also of interest:* Dabkowski, Matthew, Ronald Breiger, and Ferenc Szidarovszky. 2015. "Simultaneous-Direct Blockmodeling for Multiple Relations in Pajek." *Social Networks* 40:1-16.

## 28. Automorphic Equivalence

Borgatti, Stephen P., and Martin G. Everett. 1992. "Notions of Position in Social Network Analysis." *Sociological Methodology* 22 1-35.

Other books: Everton, *Disrupting*, 289-94 (automorphic equivalence, regular equivalence); Borgatti et al., *Analyzing*, 220-230 (regular equivalence, REGE, cores and peripheries)

## 29. Relational algebras for multiple networks

Breiger, Ronald L., and Philippa E. Pattison . 1978. "The Joint Role Structure of Two Communities' Elites." *Sociological Methods and Research* 7 (2):213-226.

Boorman, Scott A., and Harrison C. White . 1976. "Social Structure from Multiple Networks. II. Role Structures." *The American Journal of Sociology* 81 (6):1384-1446.

Wasserman & Faust, pp. 425-460.

## 30. Networks and stories

Smith, Tammy . 2007. "Narrative Boundaries and the Dynamics of Ethnic Conflict and Conciliation." *Poetics* 35 (1):22-46.

Ann Mische, "Cross-Talk in Movements: Reconceiving the Culture-Network Link" (early draft of chapter appearing as pp. 258-80 in Diani, Mario, and Doug McAdam. 2003. *Social Movements and Networks : Relational Approaches to Collective Action*. Oxford ; New York: Oxford University Press.)

Godart, Frédéric C., and Harrison C. White. 2010. "Switchings Under Uncertainty: The Coming and Becoming of Meanings." *Poetics* 38 (6):567-86.

*Optional:*

Mische, Ann. 2008. *Partisan Publics : Communication and Contention Across Brazilian Youth Activist Networks*. Princeton: Princeton University Press.

McLean, Paul Douglas. 2007. *The Art of the Network : Strategic Interaction and Patronage in Renaissance Florence*. Durham N.C.: Duke University Press.

Ch. 2 ("Networks and Stories"), pp. 20-62, in White, Harrison C. 2008. *Identity and Control : How Social Formations Emerge*. Princeton: Princeton University Press.