Sociology 952
New Methods of Social Network Analysis
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Spring 2006

DRAFT SYLLABUS: MORE STUFF HERE THAN ANYONE WILL REALLY DO!

This is a class that will cover reasonably new methods for the analysis of social network and reasonably closely related forms of data. To some extent, topics will depend on student interest and / or projects. In addition, there may be an incorporation of a "how to" component using various forms of software to carry out the techniques in question. Most of these techniques sit at the intersection of three mathematical approaches, to wit: graph theory, probability models (e.g., loglinear models), and matrix algebra. Students with no familiarity with *any* of these three will have a difficult first few weeks, but it is not necessary that students have backgrounds in all.

In sum, this is sketchy; some weeks have more practical topics that we might scrap if students aren't planning on using them; we could replace with other things or take more time for other parts. This is still pretty rough.

Requirements: Active and cheerful attendance is of course required. Students get to write a paper, which may take one of four forms. It can be (1) an application of a method to data, (2) an analytic review of work in some method that we have not covered here (either completely bracketed or further advances we have not covered, (3) an analytic comparison of the results of more than one method applied to the same data, or (4) the development of a new methodological approach. Regarding readings, we suggest buying *Social Network Analysis* by Wasserman and Faust, which we'll have at the bookstore. It won't have everything in it, but it will have a lot. We'll also try to use its companion volume, *Models and Methods in Social Network Analysis,* edited by Carrington, Scott and Wasserman

In addition, Philip Bonacich has written a text, *Introduction to Mathematical Sociology*, which is available in manuscript at his website: http://www.sscnet.ucla.edu/soc/faculty/bonacich/textbook.htm. We will use some of this too. In this syllabus, we give the standard readings for some section following a "bullet." If these aren't available on JSTOR they'll be on electronic reserve. Readings that follow a hollow circle are extensions that we probably won't be going to. Possible software solutions for some area follow a cool arrow.

I. INTRODUCTION AND MATHEMATICAL REVIEW

Week 1: Let's Remember What Math Is!

In addition to learning about student interests and beginning the process of adapting some of the later stages of the course, we will review some of the math that we'll need. We'll be revisiting these in greater detail as we get to topics that have a more intensive application.

A. What Are Social Networks?
We assume that most people will have an understanding of the basic set up—if not one may consult…
- Barry Wellman, introduction to *Social Structures: A Network Approach*.
- Ronald L. Breiger, "The Analysis of Social Networks," in Melissa Hardy and Alan Bryman (eds.), *Handbook of Data Analysis* (London: Sage, forthcoming 2003).
- Ronald Burt, *Toward a Structural Theory of Action,* chapters 1 and 9.

B. Graphs and Matrices
- Wasserman and Faust, 1-27, 69-166
- Per Hage and Frank Harary (1983) Structural Models in Anthropology. Ch 5, "Graphs and Matrices."

C. Probability
1) What is probability?
2) Cross-Classification
3) Independence and dependence
4) Conditional Probabilities
5) Writing a Statement of Probability
- Wasserman and Faust, TBA

Extra things for fanatics: chromatic number, perfect graphs.
- Gary Chartrand (1977) Introductory Graph Theory (Dover).

II. RANDOM GRAPHS

Week 2: Let's see things when they are simple!

B. Poisson Graphs

C. Sampling From Graphs 1
- M Newman, S Strogatz and D Watts. 2001. "Random Graphs with arbitrary Degree Distributions and their Applications." *Phys. Rev* E: 64.
- Steven H. Strogatz, "Exploring Complex Networks." *Nature* 410 (2001):268-276.
- Frank, "Network Sampling," Chapter 3 in Carrington, Scott and Wasserman
- Rick Grannis, "Sampling The Structure Of Large-Scale Social Networks." Unpublished Paper available on the web.
- Newman, "The Structure and Function of Complex Networks." *SIAM Review* 45:167-256.
- Also one may look at the series of articles by Peter Killworth on using the structure of networks to estimate sizes of subpopulations.

D. Small Worlds
1) Review of Idea
   - Stanley Milgram. 1967. "The Small World Problem." *Psychology Today* 2:60-67.

- Killworth, Peter D. and H. Russell Bernard. 1979. "A Pseudomodel of the Small World Problem." *Social Forces* 58:477-505.

2) Formalization
   - Duncan J. Watts. 1999. "Networks, Dynamics, and the Small-World Phenomenon." *American Journal of Sociology* 105: 493-527.
   - Duncan J. Watts. 1999. *Small Worlds: The Dynamics of Networks between Order and Randomness*. Princeton: Princeton University Press.

3) Problems on Small Worlds
   - Watts, Duncan J., Peter Sheridan Dodds, and M.E.J. Newman. 2002. "Identity and Search in Social Networks." *Science* 296: 1302-1305.

- PAJEK
- MATLAB

III. COHESION

Week 3: Let's get connected!

B. Percolation problems
- P.S. Dodds and D.J. Watts, "A generalized model of social and biological contagion," *Journal of Theoretical Biology* 232 (2005) 587–604.
- Duncan J. Watts, "A simple model of global cascades on random networks." *Proceedings of the National Academy of Sciences*, vol. 99, no. 9, pp. 5766-5771 (2002)

C. n-cliques, n-clans, edge connectivity
- Wasserman and Faust, Ch 7
- Borgatti, S. P., M. G. Everett, and P. R. Shirey (1990). "LS sets, lambda sets, and other cohesive subsets." *Social Networks* 12, 337–358.
- White, D.R. and Harary, F. (2001) "The cohesiveness of blocks in social networks: node connectivity and conditional density." *Sociological Methodology* 2001, 31, 305-359.

D. A new approach
- James Moody and Douglas White (2003) "Group Cohesion, Nesting, and Embeddedness" *American Sociological Review* 68: 103-127.
- James Moody. 2004. "The Structure of A Social Scientific Collaboration Network." *American Sociological Review* 69:213-238.

- UCINET
- OTHERS

IV. PROBABILITY MODELS

Week 4: Let's Approach Real Data!

B. Theoretical Refresher—Balance Theory
- Fritz Heider. 1946. "Attitudes and Cognitive Organization," *Psychological Review* 52:358-374

- Dorwin Cartwright and Frank Harary. 1956. "Structural Balance," *Psychological Review* 63:277-293*
- Frank Harary. 1955. "On Local and N-balance of Signed Graphs," *Michigan Mathematical Journal* 5:37-41.
- Wasserman and Faust, 220-247* (skim what you understand from Cartwright and Harary).

C. Methodological Refresher—Matrix Algebra

D. Models for local structure—Triad Analysis

- Wasserman and Faust, 564-575, 581-582 (may skim)

- Paul Holland and Samuel Leinhardt. 1970. "A Method for Detecting Structure in Sociometric Data" *American Journal of Sociology* 76: 492-513.
- Ivan D. Chase. 1980. "Social Processes and Hierarchy Formation in Small Groups: A Comparative Perspective." *American Sociological Review* 45:905-924.*
- James Davis and Samuel Leinhardt. 1972. "The Structure of Positive Interpersonal Relations in Small Groups." In Joseph Berger, Morris Zelditch, Jr., and Bo Anderson (eds.), *Sociological Theories In Progress Volume 2*, Boston: Houghton Mifflin, pp. 218-251,
- Paul Holland and Samuel Leinhardt. 1971. "Transitivity in Structural Models of Small Groups." *Comparative Group Studies* 2: 107-124,
- Paul Holland and Samuel Leinhardt. 1976. "Local Structure in Social Networks," *Sociological Methodology 1976*: 1-45
- Eugene Johnsen. 1985. "Network Macrostructure Models for the Davis-Leinhardt Set of Empirical Sociomatrices." *Social Networks* 7: 203-224.
- UCINET
- DAMN

E. Individual Level Models—p_1 Models

- Wasserman and Faust, TBA
- Paul Holland and Samuel Leinhardt, "An Exponential Family of Probability Distributions for Directed Graphs." *Journal of the American Statistical Association* 76(1981):33-50
- Stanley Wasserman and Dawn Iacobucci. "Statistical Analyses of Discrete Relational Data." *British Journal of Mathematical and Statistical Psychology* 39 (1986):41-64
- See Chapter 15 by Iacobucci in Wasserman and Faust for extended p_1 models,
- p_2 models: Lazega, Emmanuel, and Marijtje A. J. van Duijn. 1997. "Position in Formal Structure, Personal Characteristics and Choices of Advisors in a Law Firm: A Logistic Regression Model for Dyadic Network Data." *Social Networks* 19:375-397.
- other stochastic models
- UCINET
- SPSS

Week 5: Let's Make it Messy!

F. *p** models

- Wasserman and Robins, Chapter 8 in Carrington, Scott and Wasserman.
- Koehyly and Pattison, Chapter 9 in Carrington, Scott and Wasserman.
- Robins and Pattison, Chapter 10 in Carrington, Scott and Wasserman.
- Wasserman, Stanley, Carolyn J. Anderson, and Bradley Crouch. 1999. "A *p** Primer: Logit Models for Social Networks." *Social Networks* 21:37-66.
  - Wasserman, Stanley, and Philippa Pattison. 1996. "Logit Models and Logistic Regressions for Social Networks: I. An Introduction to Markov Graphs and *p**."
  Psychometrika 61:401-425.
  - Pattison, Philippa, and Stanley Wasserman. 1999. "Logit models and logistic regressions for social networks: II. Multivariate relations." *British Journal of Mathematical and Statistical Psychology* 52: 169-193.
  - On MCMC methods see Handcock in the dynamic social book,
  - And also Tom A B Snijders. 2002. "Markov Chain Monte Carlo Estimation of Exponential Random Graph Models." *Journal of Social Structure* 3:2.
  - SPSS for pseudolikelihood
  - DAMN for multimatrix pseudolikelihood

G. Models for Samples

- Koehly, Goodreau and Morris. "Exponential Family Models for Sampled anad Census Network Data." *Sociological Methodology* 34(2004): 241-270.

V. MARKOV CHAINS

Week 6: Let's Get Dynamic!

B. Review—Matrix Algebra and Markov Chains

- Bonacich, Ch 4 (Matrices) and Ch 9 (Markov Chains)
  - Ian Bradley and Ronald L Meek (1986) Matrices and Society (Pelican).

C. Applications—Networks as Markov States

- Thomas J Fararo and John Skvoretz (1986) "E-State Structuralism: A Theoretical Method," *American Sociological Review* 51:591-602.
- Robins, G.L., Woolcock, J., & Pattison, P. (2005). Small and other worlds: Global network structures from local processes. *American Journal of Sociology, 110,* 894-936.
  - Snijders, Chapter 11 in Carrington, Scott and Wasserman.

Week 7: Let's Get Opinionated!

C. Application—Opinion Formation

- Noah E Friedkin and Eugene C Johnsen (1997) "Social Positions in Influence Networks," *Social Networks* 19:209-222.
  - Noah Friedkin (1998) A Structural Theory of Social Influence (Cambridge)

D. Dynamics of Network Balance

  - Flament (1963) Applications of Graph Theory to Group Structure (Prentice Hall)
  - Abell (1969?)

- Maurice T. Hallinan and Edwin E. Hutchins (1980) "Structural Effects on Dyadic Change." Social Forces 59: 225-245.
- Patrick Doreian and Andrej Mrvar (1996) "A Partitioning Approach to Structural Balance," *Social Networks* 18:149-168.
- Doreian P, Kapuscinski R, Krackhardt D, et al. (1996) "A brief history of balance through time," J Math Soc 21 (1-2): 113-131.
- Doreian P, Krackhardt D (2001), "Pre-transitive balance mechanisms for signed networks ," J Math Soc 25 (1): 43-67 2001.

VI. PRACTICAL THINGS #1

Week 8: Let's Do A Paper!

B. Putting like things together

1) Matrix Algebra—Singular Value Decomposition
2) RC Models
   - Leo A. Goodman 1979. "Simple Models for the Analysis of Association in Cross-Classifications Having Ordered Categories." *Journal of the American Statistical Association* 74:537-552.
   - Goodman, Leo A. 1981. "Association Models and Canonical Correlation in the Analysis of Cross-Classifications Having Ordered Categories." *Journal of the American Statistical Association* 76: 320-334.
   - Goodman, Leo A. 1985. "The Analysis of Cross-Classified Data Having Ordered and/or Unordered Categories: Association Models, Correlation Models, and Asymmetry Models for Contingency Tables With or Without Missing Entries." *The Annals of Statistics* 13:10-69.

   - *l*EM
   - STATA

3) Correspondence Analysis
   - Greenacre, Michael J. 1988. "Clustering the Rows and Columns of a Contingency Table." *Journal of Classification* 5:39-51.
   - Faust, Chapter 7 in Carrington, Scott and Wasserman

   - Wasserman, Stanley, Katherine Faust and Joseph Galaskiewicz. 1989. "Correspondence and Canonical Analysis of Relational Data." *Journal of Mathematical Sociology* 1:11-64.

   - Goodman, Leo A. 1996. "A Single General Method for the Analysis of Cross-Classified Data: Reconciliation and Synthesis of Some Methods of Pearson, Yule, and Fisher, and Also Some Methods of Correspondence Analysis and Association Analysis." *Journal of the American Statistical Association* 91:408-428.

   - Goodman, Leo A. 1997. "Statistical Methods, Graphical Displays, and Tukey's Ladder of Re-Expression in the Analysis of Non-Independence in Contingency Tables: Correspondence Analysis, Association Analysis, and the

Midway View of Nonindependence." Pp. 101-132 in *The Practice of Data Analysis: Essays in Honor of John W. Tukey*, edited by D. R. Brillinger, L. T. Fernholz and S. Morgenthaler. Princeton: Princeton University Press.

- Noma, Elliot and D. Randall Smith. "Scaling Sociomatrices by Optimizing an Explicit Function: Correspondence Analysis of Binary Single Response Sociomatrices." *Multivariate Behavioral Research* 20:179-197.

- Roberts, John M. 2000. "Correspondence Analysis of Two-Mode Network Data." *Social Networks* 22:65-72.

- MOST PACKAGES
- UCINET

VII. STRATEGIC NETWORK FORMATION [MONTGOMERY]

Week 9: Let's Get Utilitarian!

A. Two-Sided Matching

- Dale Mortensen (1988) "Matching: Finding a Partner for Life or Otherwise," American Journal of Sociology 94: S215-S240.
- Gary S Becker, Treatise on the Family, Ch 4, "Assortive Mating in Marriage Markets"
- Roth and Sotomayer, *Two-Sided Matching*

Week 10: Let's Get Strategic and Dynamic!

B. Pairwise Stability

- Matthew Jackson and Asher Wolinsky (1996) "A Strategic Model of Social and Economic Networks," Journal of Economic Theory 71:44-74.
- Matthew Jackson and A Watts (2002) "The Evolution of Social and Economic Networks," Journal of Economic Theory 106:265-95.
- Matthew O Jackson (2005) "The Economics of Social Networks," Cal Tech working paper, posted at http://www.hss.caltech.edu/~jacksonm/netect.pdf

C. Application—Burt's "Structural Holes" Argument

- Vincent Buskens and Arnout van de Rijt (2005) "Dynamics of Networks if Everyone Strives for Structural Holes," University of Utrecht working paper.
- Sanjeev Goyal and Fernando Vego-Redondo (2004) "Structural Holes in Social Networks," University of Essex working paper.
- Ronald Burt, *Structural Holes*, Intro, Chapter 1.

Semi-Preferential Attachment

- Roger Gould, 2002. "The Evolution of Status Hierarchies." *American Journal of Sociology* 107: 1143-1178.

VI. PRACTICAL THINGS CONTINUED!

Week 14: Let's Make a Picture!

4) Multidimensional Scaling
   - Kruskal, J.B. and M. Wish 1978. *Multidimensional Scaling*. Sage, pp. 7-30, 48-60.
   - Guttman, Louis A. 1968. "A General Non-metric Technique for Finding the Smallest Coordinate Space for a Configuration of Points." *Psychometrika* 33: 495-506.
   - Freeman, Chapter 12 in Carrington, Scott and Wasserman.

   - UCINET (nonmetric)
   - STATA (metric)
   - INDSCAL

B. Clustering from probability models
   - Goodman, L. 1981. "Criteria for determining whether certain categories in a cross-classification table should be combined, with special reference to occupational categories in an occupational mobility table." *American Journal of Sociology* 87:612-650.
   - Ronald L. Breiger and John W. Mohr, "Institutional Logics from the Aggregation of Organizational Networks: Operational Procedures for the Analysis of Counted Data." *Computational & Mathematical Organization Theory* 10 (2004): 17–43.

Week 15: Let's Get Published!

C. Doing Regressions on Network Data
   - Krackhardt, David. 1987. "QAP Partialling as a Test of Spuriousness." *Social Networks* 9:171-186.
   - Krackhardt, David. 1988. "Predicting with Networks: Nonparametric Multiple Regression Analysis of Dyadic Data." *Social Networks* 10:359-381.

   - Baker, Frank B., and Lawrence J. Hubert. 1981. The Analysis of Social Interaction Data: A Nonparametric Technique. *Sociological Methods and Research* 9:339-361.
   - Hubert, L. 1985. Combinatorial Data Analysis: Association and Partial Association. *Psychometrika* 50:449-467.
   - Hubert, Lawrence, and James Schultz. 1976. Quadratic Assignment as a General Data Analysis Strategy. *British Journal of Mathematical and Statistical Psychology* 29:190-241.
   - Krackhardt, David. 1992. A Caveat on the Use of the Quadratic Assignment Procedure. *Journal of Quantitative Anthropology* 3:279-296.

   - STATA
   - DAMN

VIII. CENTRALITY

Week 12: Let's Learn Something!

B. Review and Augment our math…
   1) Matrix Algebra—Eigenvectors and Eigenvalues

C. Centrality
   1) review of idea of centrality
      - Wasserman and Faust
      - Bell, D. C., J. S. Atkinson, and J. W. Carlson. 1999. "Centrality Measures for Disease Transmission Networks." *Social Networks* 21:1-21.
      - Bolland, J. M. 1988. "Sorting Out Centrality: An Analysis of the Performance of Four Centrality Models In Real and Simulated Networks." *Social Networks* 10:233-53.
      - Linton Freeman. 1977. "A Set of Measures of Centrality Based on Betweenness." *Sociometry* 40:35-41.
      - Linton Freeman. 1978-1979. "Centrality in Social Networks." *Social Networks* 1:215-39.
      - Friedkin, Noah. E. 1991. "Theoretical Foundations for Centrality Measures." *American Journal of Sociology* 96:1478-504.

   2) eigenvector centrality
      - P. Bonacich, "Power and Centrality: A Family of Measures," *American Journal of Sociology* 92(1987):1170-1182.
      - P. Bonacich and P. Lloyd. 2001. "Eigenvector-like measures of centrality for asymmetric relations." *Social Networks* 23: 191-201

   3) Further extensions
      - Everett and Borgati, Chapter 4 in Carrington, Scott and Wasserman

   - UCINET
   - MATLAB

Week 10: Let's Get Deep!

D. Equivalence
   1) Structural
      - Wasserman and Faust, 345-361 (look at 361-391), 394-423.

      - Francois Lorrain and Harrison White. 1971. "Structural Equivalence of Individuals in Social Networks." *Journal of Mathematical Sociology* 1:49-80.
      - Harrison White, Scott Boorman, and Ronald Breiger, "Social Structure from Multiple Networks I: Blockmodels of Roles and Positions." *American Journal of Sociology* 81 (1976):730-779
      - Ronald Breiger, Scott Boorman, and Phipps Arabie, "An algorithm for clustering relational data…", *Journal of Mathematical Psychology* 12(1975):328-383
      - Ronald Burt, "Positions in Networks," *Social Forces* 55(1976):93-122.
   - CONCOR

- UCINET

2) Regular
   - Wasserman and Faust, TBA
   - Patrick Doreian (1988) "Equivalence in a Social Network" *Journal of Mathematical Sociology* 13: 242-282.
   - Doreian, Batagelj and Feligoc, Chapter 5 in Carrington, Scott and Wasserman

The motivated student may also investigate automorphic and stochastic equivalences.

IX. ALGEBRAIC APPROACHES

Week 11: Let's Get Smart!

B. Review—Algebra and Sets
   - Ronald Breiger, "The Duality of Persons and Groups," *Social Forces* 53(1974):181-90

C. Galois Algebras
   - Linton C Freeman and Douglas R White (1993) "Using Galois Lattices to Represent Network Data," *Sociological Methodology* 23:127-146.
   - King-To Yeung, "The Duality of Persons and Relationships." *Social Forces* 2005.
   - GLAD
   - ELLA

D. Kinship Algebras
   1) How are relations algebras
   2) Is there a logic
      - John Paul Boyd (1969) "The Algebra of Group Kinship" *Journal of Mathematical Psychology* 6:139-167.

   - Claude Levi-Strauss, *The Elementary Structures of Kinship*, pp. 12-83, 119-133, 146- 220, 232-309. (Chs. 2-6, 9, 11-13, 15-17).*
   - Harrison White, *An Anatomy of Kinship*
   - Franklin E. Tjon Sie Fat, 1990. *Representing Kinship: Simple Models of Elementary Structures*. Published Dissertation. Leiden: Leiden University.

Week 12: Can We Possibly Get THIS Smart?

E. Role Algebras
   - R.L. Breiger and P.E. Pattison. 1986. "Cumulated Social Roles: The Duality of Persons and Their Algebras," *Social Networks* 8 : 215-256

   - S. F. Nadel, *Social Structure*, 1-19, 62-73, 79-92, 97-104, 147-152.
   - Scott Boorman and Harrison White. 1976. "Social Structure from Multiple Networks II: Role Structures." *American Journal of Sociology* 81:1384-1446.
   - Philippa Pattison. 1994. *Algebraic Models for Social Networks.* Cambridge.

F. Logic as Algebra
Unclear exactly what we might do here….
- Ragin, *The Comparative Method*, selections
  - Nonmonotonic Logic?
  - Semantic Grammars