Ties & Bonds

BBS ***[Barry's Bulletin-Board Service]***

Caroline Haythornthwaite promoted to Assoc Prof with tenure, Lib & Info Sci, U Illinois Champaign-Urbana..... **Leah Lievrouw** promoted to Full Prof (Info Studies, UCLA) ..... **Bob Putnam** (JFK Schl, Harvard) spending 2002-2003 at Cambridge (the real one).... **Shinsuke Otani** (Soc, Kwansei Gakuin U) spending 4-9/02 at Centre for Urban & Community Studies, U of Toronto < sotani@kwansei.ac.jp>. He's an expert on Japanese urban networks and survey research .... **Naomi Yamashita** (NTT & Kyoto U) spending the 02-03 academic year at McMaster U (near Toronto) where her husband has a computer sci dept visiting profship.... **Carter Butts & Joy Pixley** to become Asst Profs of Sociology at Univ of California Irvine, Summer 2002.... **Dimitrina Dimitrova** (Soc, Toronto) received her doctorate, 3/02, for her studying of "The Telework Mosaic: Forms of Corporate Telework." <dima@chass.utoronto.ca>.... **Joe Walther** moved from Rensselaer Poly. to new department of Communication at Cornell, 9/02 .... **Arent Greve** promoted to Full Prof at Norwegian School of Econ & Bus Admin (Bergen) 9/02.... **Caroline Haythornthwaite** now serving as Interim Associate Dean of U Illinois' Grad Schl of Library and Information Science.

John Scott (Essex) current president of British Soc Assoc.... **Michael Burawoy** (U Cal-Berkeley) elected Pres & **Bernice Pescosolido** (Indiana U) elected VP of Amer Soc Assoc... **Ron Aminzade** (U Minnesota) & **Karen Campbell** (Vanderbilt U) elected to ASA's Committee on Nominations.... **Kieran Healy** (Princeton) wins ASA Dissertation Award for "Exchang in Blood and Organs' (hopefully without transitivity).... Former INSNA Associate Ed. & Coordinator **June Corman** promoted to Full Prof, Soc, Brock U, St. Catharines, Ont, Canada. Her book with Meg Luxton, *Getting By in Hard Times: Gendered Labour at Home and on the Job* .... **Fabio Fonti** now Asst Prof of Organizational Studies, Bus School, Boston College.... **Amalya Oliver-Lumerman** incoming chair of Soc, Hebrew U..... **Brian Uzzi** (B-school, Northwestern U) winner of best paper award for "Embeddedness in the Making of Financial Capital: How Social Relations and Networks Benefit Firms Seeking Financing," *(American Sociological Review)* – this "W. Richard Scott" award is from Organization, Occupation and Work section of Amer Soc Assoc..... **Norm Hummon** (Soc, Pittsburgh U) died after a lengthy bout with cancer, Aug 02. I saw Norman this spring when I lectured in Pittsburgh, and he was straightforward about his situation, active and in good spirits.

In Memory of Jack Richardson, Ph.D.

Univ of Toronto, 1984. Died after a Short Illness, March 9, 2002.

Jack Richardson was my student — and my mentor.

My most vivid memories of Jack are during his graduate student life. Jack shared my office then while writing his doctoral thesis about interlocking corporate relationships, a matter that Imperial Oil had taught Jack a lot about. Whenever I walked into our office, Jack was always there. He looked up and smiled, and then put his head back down to work.

Not only was Jack one of the clearest and most original thinkers I knew, he was absolutely the most disciplined. He proceeded to get his Bachelor's, Master's and Doctorate at the University of Toronto in short order following a carefully-structured plan. When we worked together, he had a schedule up next to his desk on which date each chapter of his thesis would be finished. Sure enough, each chapter was finished – and finished well — by the prescribed date, and the thesis was smart, brilliant stuff. The final thesis, "Toward a `Structural-Rational' Theory of the Functions of Directorship Interlocks," was a milestone in helping us to understand how relationships between corporations worked. His key argument was that when a board member of a firm was quickly replaced by another member of the firm, there was strong indication of an ongoing inter-corporate relationship.

No wonder that I grabbed him to collaborate with me on a big review article about social network analysis in Canada: "Structural Analysis: The State of Canadian Art". He collaborated so fully and so well, he became the first author, and the article has held up well. It's in the *Canadian Review of Sociology and Anthropology* 22, 5 (1985):771-93. [Special issue on "The State of the Art in Anglophone Canadian Sociology"].

Jack was a quietly wonderful manager, able to see needs, meet them, and show leadership while maintaining the love of his colleagues. He stepped in quietly, efficiently and effectively whenever needed. Even though he left Imperial Oil, he couldn't escape his responsibility. After finishing his part-time B.A. at Woodsworth College, they put him on their board. When he came to graduate school, he did a great stint with me as Associate Coordinator of the International Network for Social Network Analysis and its *Connections* journal. He saw that he was needed, and he just came through. And when McMaster appointed him as he finished, he wound up running *two* departments.

Was herding sociologists what Jack had escaped Imperial Oil for? Fortunately, Jack was a great sociologist and a great manager. He turned out highly-regarded journal articles after his thesis about how corporations and financial institutions work. They are models of professional work: well thought out, heavily researched, and well argued.

Jack was not all work and no play. He had a zest for life, whether running track to keep his wonderfully athletic physique or being with Enid. His warmth enveloped me whenever we intersected. I can continue to read his work, but alas I will miss him always as a person.

Short Schticks

Networkers Networking: The UK's "Social Science Information Gateway" asks experts to choose favorite websites. If you want to see one networker choosing another's, go to www.sosig.ac.uk/experts-choice/experts/duncan_timms.html, where Dean **Duncan Timms** (Soc, Stirling) chooses **Barry Wellman's** (www.chass.utoronto.ca/~wellman)

Job Opportunities for Network Analysts: "Al Qaeda has mutated into a form that is no less deadly and even more difficult to combat. 'We are confronted with cells that are all over the place, developing in a very horizontal structure without any evident big center of coordination,' a top European counterterrorist investigator" said [*Newsweek,* 12Aug02, www.msnbc.com/ news/ 791852.asp?cp1=1 #BODY]

CONNECTIONS 25(1): 7-26

StOCNET: Software for the statistical analysis of social networks[1]

Mark Huisman and Marijtje A.J. van Duijn [2]
ICS / Statistics & Measurement Theory, University of Groningen, the Netherlands

StOCNET[3] is an open software system in a Windows environment for the advanced statistical analysis of social networks. It provides a platform to make a number of recently developed and therefore not (yet) standard statistical methods available to a wider audience. A flexible user interface utilizing an easily accessible data structure is developed such that new methods can readily be included in the future. As such, it will allow researchers to develop new statistical tools by combining their own programs with routines of the StOCNET system, providing a faster availability of newly developed methods.

In this paper we show the current state of the developments. The emphasis is on the implementation and operation of the programs that are included in StOCNET: BLOCKS (for stochastic blockmodeling), p2 (for analyzing binary network data with actor and/or dyadic covariates), SIENA (for analyzing repeated measurements of social networks), and ZO (for calculating probability distributions of statistics). Moreover, we present an overview of future contributions, which will be available in the near future, and of planned activities with respect to the functionality of the StOCNET software. StOCNET is a freeware PC program, and can be obtained from the StOCNET website at http://stat.gamma.rug.nl/stocnet/.

INTRODUCTION

At the Sunbelt XX conference in Vancouver, Zeggelink, Snijders, and Boer (2000) announced the development of an open software system called StOCNET for the advanced statistical analysis of social networks. Two years later, at the Sunbelt XXII conference in New Orleans, an update of the project was given by Huisman and Van Duijn (2002). Now, we are presenting the newest release: StOCNET Version 1.4 (Boer, Huisman, Snijders, and Zeggelink, 2002).

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[1] This paper was presented at the 23rd Biennial Conference of the Society for Multivariate Analysis in the Behavioral Sciences, Tilburg, The Netherlands, July 1-3, 2002.

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[3] The development of StOCNET is supported by the Dutch Research Council (NWO), grant 400-20-020.

Many different methods that exist for the analysis of social networks are covered by programs like GRADAP (Sprenger and Stokman, 1989), NetMiner (Cyram, 2002), Pajek (Batagelj and Mrvar, 2002), or UCINET (Borgatti, Everett, and Freeman, 1999). However, a number of recently developed statistical methods and the accompanying computer programs have not yet reached (potentially interested) empirical researchers in social networks. The main reason is that most of these methods are available in privately owned programs that are not quite fit for public distribution. StOCNET provides a Windows platform to make these statistical methods freely accessible.

In this paper the current state of the StOCNET software is presented. A general and flexible data structure and user interface were developed such that new methods can easily be included and new tools can be developed by combining existing programs with routines of the StOCNET system. At this moment, the latest release of StOCNET, Version 1.4, contains five statistical methods for social network analysis:

- BLOCKS, for stochastic blockmodeling of relational data (Nowicki and Snijders, 2001).
- p_2, for the analysis of binary network data with actor and/or dyadic covariates and random effects (Van Duijn, 1995).
- SIENA, for the statistical analysis of longitudinal network data (Snijders, 2001).
- ULTRAS, for estimating latent transitive structures in social networks (Schweinberger and Snijders, forthcoming).
- ZO, for determining probability distributions of statistics of random graphs (Snijders, 1991; Molloy and Reed, 1995).

These modules are presented in this paper. Furthermore, modules that will be available in the near future are mentioned, as well as other functionalities of the StOCNET software to be implemented.

The paper starts with a brief introduction to the StOCNET project. In the following section, the current version of StOCNET (version 1.4) is presented. The supported options are described and an example data set consisting of friendship networks between university freshmen is used to illustrate the StOCNET software.

The statistical methods forming the core of the StOCNET software are introduced in Section 3: BLOCKS, p_2, SIENA, ULTRAS, and ZO. The university freshmen data were analyzed with these procedures, and some results are presented. In Section 4 the Examine functionality, which gives the user the possibility to explore the network and covariate data is described. In Section 5, planned activities with respect to new procedures and functionalities are introduced, and the paper ends with directions for potential contributors and the presentation of the StOCNET website.

1. THE StOCNET PROJECT

Methods for the analysis of social networks are not covered in standard statistical packages. A number of software packages were specifically designed for social network analysis. The most widely known and widely used programs are GRADAP (Sprenger and Stokman, 1989), Pajek (Batagelj and Mrvar, 2002), and UCINET (Borgatti, Everett, and Freeman, 1999). Other (less well known and

more specialized) programs are FATCAT (Richards and Seary, 1993), MultiNet (Richards and Seary, 2000), NetMiner (Cyram, 2002), and STRUCTURE (Burt, 1991) [4]. These programs contain many state-of-the-art analysis methods, but they cover only specialized methods, or the coverage of established methods is not complete. Especially, and not surprisingly, recently developed statistical methods are underrepresented in these programs. Stimulated by general developments in statistical analysis that were facilitated by expanded computing force, such as Gibbs sampling, computer-intensive techniques have proved to be quite important contributions. These methods are usually implemented in computer programs constructed by their developers, which are not always easily available or easy to use, and usually miss sufficient documentation. Therefore, the methods have not yet (or hardly) reached the empirical social network researchers. For a comprehensive overview of software available for social network analysis, see Huisman and Van Duijn (2003).

The purpose of the StOCNET project is the development of an open software system for the advanced statistical analysis of social networks. The system serves three goals:

- the incorporation of important recently developed statistical methods for network analysis in user-friendly and easily available software,
- more efficiency in the implementation of such new methods by setting up a system with a common data structure and a common user interface, and
- faster availability of new methods.

The aim is not competition with but complementarity to other social network analysis software. Whereas other programs are usually closed systems offering a wide range of mostly non-statistical methods, StOCNET is an open system focusing on more advanced statistical methods. Partly because of their being based on simulation methods, these methods require more expertise of the user.

A second aspect of the StOCNET project is the definition of requirements and formulation of instructions for potential contributors to the system. The definition of requirements is aimed at user-interface, data definition, and output, thus developing StOCNET standards, with the purpose of reducing the programming task of the contributor. The requirements also include (precise) documentation of the method, which is facilitated because the set-up of the program, data definition, and technical specifications are already documented in StOCNET.

2. THE StOCNET SYSTEM

2.1 StOCNET sessions

An analysis within StOCNET takes place within a so-called session, and usually consists of five more or less sequential steps. The steps start with the data definition and result in specified output, after which all or some steps can be repeated. Within a session the user generally uses the same (selection of) data sets. Transformations, selections and the latest model specifications for these data are all saved by saving the session, and can easily be activated again when opening the same session a second time.

For most users, the sequential process of five steps will soon become a cyclic process, possibly skipping certain steps. The interactive features of StOCNET imply that any revised analysis can easily

[4] Some of these programs are available as freeware: see the INSNA website at http://www.sfu.ca/~insna/.

be undertaken in the current session or in a new session. The different steps in a session are entered by clicking the corresponding buttons in the StOCNET-toolbar (see Figure 1).

Step 1. *Data definition*: Specification and description of the network(s) and the actor attributes in separate data files. In this step, the network data and the attribute data are specified. Both may be contained in multiple data files. The network must be presented as an adjacency matrix (saved) in ASCII format. This means that each network is presented by n lines with n integer numbers separated by blanks, and each line is ended by a hard return. Once a file has been selected, the network in that file is added to the set of available networks for that session. The same holds for attribute files (actor and/or dyadic attributes). For k actor covariates, the data file must contain n lines, with on each line k numbers separated by blanks which are read as real numbers. This data definition was chosen because most current statistical methods require networks with not more than moderately many nodes (up to a few hundred[5]). The StOCNET user-interface for this step is presented in Figure 1.

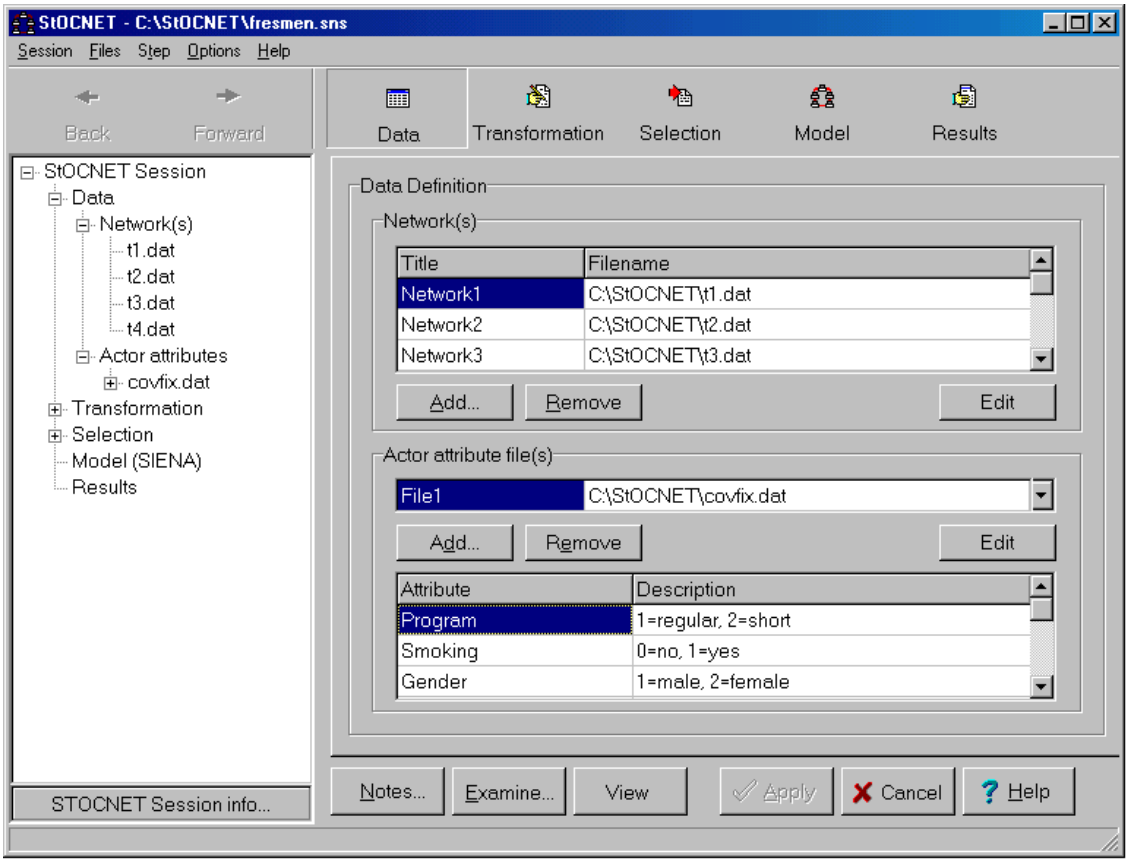

Figure 1. Step1 in a StOCNET session – Data definition.

Step 2. *Transformation*: Recoding network values and/or actor variables and specification of missing values. A full recode functionality is implemented to transform all available data (network and attributes). Also missing value codes can be defined (multiple codes for network values). How the missing values are treated depends on the procedure chosen for the analysis. The only thing

[5] In programs that are designed to handle large networks like Pajek or MultiNet, data are usually defined by node and link (arcs/edges) lists.

StOCNET does in this respect is to pass on the code to the module. All transformations can be inspected by clicking the View-button to examine the data. The transformed data is saved in a temporary file with the same name as the old file preceded by '~'. These files can also be saved under different names.

Step 3. *Selection*: Selection of actors based on several possible criteria. There are four different ways to select a set of actors:

1. Select all *n* actors that are available in the specified network files.
2. Define a subset of actors by specifying a range of actors, for instance, the first ten or twenty actors in the adjacency matrix. The program will automatically select the corresponding rows and columns of the network data.
3. Selection based on the values of the attributes. For instance, using the attribute gender, the female actors can be selected. For this purpose, first the attribute file containing the desired covariate has to be specified then the covariate and its value to use as selection criterion.
4. The last selection method is the most complex one. It involves an examination of the network data and computation of some network statistics. Subsequently a subset of actors is selected that fulfills a certain network requirement. The current version of StOCNET, only the selection of actors based on their in- or out-degree is supported.

Selections can be examined and saved the same way as transformations.

Step 4. *Model specifications and analysis*: Choice of the program for data analysis, specification of the model parameters in the model specific user interface, and running the method. The models that are available in the current version are described in Section 3.

Step 5. *View results*: Inspection of the output and results from the analyses. StOCNET allows for a structured view through the output by selecting certain output items. The items are indicated in the output file by the symbol @1 for chapters, @2 for sections, @3 for sub-sections, and so on. These items are shown in the session-tree in the left part of the StOCNET window, and the user can select an item by double clicking on it.

In every step of a StOCNET session, the session-tree (or history-tree) contains global information on the history of the present session. The session-tree is shown in the left part of the window. The operation of this tree is similar to standard options in Windows Explorer, with the difference that here an overview is given of actions taken together with details of these actions. The details can be viewed by clicking the corresponding '+'. Double clicking the step name results in a move towards the corresponding step in this session. The session-tree is shown in Figure 1.

2.2 Menu bar

The menu bar of the StOCNET program consists of four items. The first one, labeled *Session*, and the last one, labeled *Help* are standard Windows functionalities for opening/saving files (sessions) and on-line help, respectively. The Session-menu also contains Export functions to other network programs. In order to exploit the large amount of methods and statistics that are available in other programs (e.g., UCINET, Pajek, or NetMiner), and especially the graphical procedures in some of

these programs,[6] export functions are included in the new version of StOCNET. Thus input files are created that can easily be used in MultiNet (Richards and Seary, 2002), NetMiner (Cyram, 2002), Pajek (Batagelj and Mrvar, (2002), and STRUCTURE (Burt, 1991).

With the second item, labeled *Step*, the consecutive steps in a StOCNET session are entered. These steps are also available via separate buttons in the StOCNET-toolbar (see Figure 1). The third option, labeled *Options*, contains options to set the toolbar on or off and to set working directories.

2.3 Example: friendships between university freshmen

Van Duijn, Huisman, Stokman, Wasseur, and Zeggelink (2003) studied friendship relations in a network of freshmen students. The data were collected at five time points during the years 1996 and 1997, and are repeated measures of the friendship network of 38 Dutch university freshmen in sociology. The dichotomized relation studied is defined as 'at least a friendly relationship'.

Friendship data were collected at five time points: at the start of the academic year, and next at 3, 6, 13, and 35 weeks after the start of the year, respectively. We refer to these observation times as t_1 to t_5. Although most students did not know each other at the beginning of the year, some relationships already present at t_1 are taken into account. At the observation times, the relations of 38, 25, 26, 18, and 18 students, respectively, were completely observed[7].

At t_1 actor attribute data were collected. Three groups of attribute variables were distinguished: 1) opportunity variables (study program, smoking behavior), 2) visible attributes (gender), and 3) invisible attributes (doing sports, watching sports, playing music, religious involvement, club membership, study orientation, and social orientation); see Van Duijn et al. (2003) for a detailed description of all variables. Figure 1 shows the definition of the freshmen data in StOCNET.

3. IMPLEMENTED MODULES

3.1 BLOCKS

The module BLOCKS (version 1.53) is designed for stochastic blockmodeling of relational data according to the methods described in Nowicki and Snijders (2001). For more detailed information on the program BLOCKS or stochastic blockmodeling, the reader is referred to Nowicki and Snijders (2001) and to the user's manual of BLOCKS (Snijders and Nowicki, 2001).

Posterior blockmodeling consists of finding equivalent groups of actors (with respect to relational patterns) based on the observed relations between the actors. When the observed data are assumed to be generated by some stochastic mechanism, this approach to blockmodeling is called stochastic blockmodeling. The method implemented in BLOCKS tries to find out – a posteriori – how many different (latent) classes of actors can be distinguished and which actors belong together in the same class by estimating the posterior probability distribution of the configuration of the class structure given the network data. The parameter estimates are obtained with Gibbs sampling.

[6] It was decided not to develop a graphical module for the StOCNET system because of the large amount of programming time it would require, and the availability of other programs with good graphic procedures.

[7] Between t_3 and t_4 one student left the network due to a change of discipline. The program SIENA can handle this kind of composition change (Huisman and Snijders, 2002).

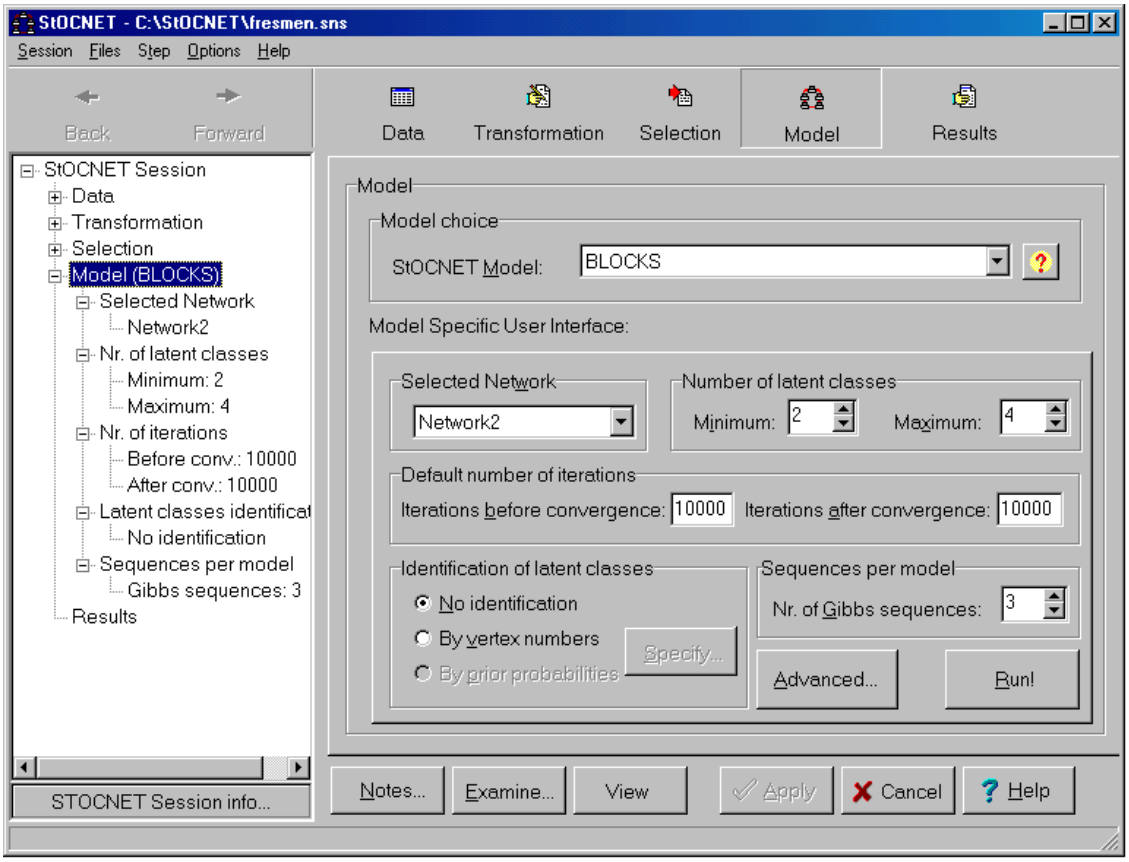

Figure 2. BLOCKS – Model-specific user interface.

In Figure 2 the model-specific user interface for BLOCKS is shown. The options to be specified by the user are the network data set, the number of latent classes, the number of iterations, and the number of Gibbs sequences in the estimation procedure. If prior information is available on the latent classes, the classes can be identified. Identification can be accomplished in two ways: 1) by specifying for each class one vertex number that has a high probability of belonging to that class, or 2) by specifying prior probabilities for a vertex to belong to a certain class.

University freshmen

The data observed on t_2 are analyzed with the program BLOCKS to find distinct groups of students. Solutions with 2, 3, and 4 blocks of students were studied. In Table 1 the values of two fit indices, I_y and H_x (Nowicki and Snijders, 2001), are presented; I_y indicates the extra information contained in observing the relations, if grouping is known a priori; H_x indicates the clarity of the block structure. The indices have values between 0 and 1, with 0 indicating a good fit.

Table 1: Goodness-of-fit of three blockmodels.

Blocks	I_y	H_x
2	0.633	0.673
3	0.572	0.576
4	0.558	0.500

Inspection of the fit indices shows that there is little improvement in model fit if more than 2 blocks are distinguished. Other results of the analysis (not reported here), show that the 2 blocks solution is the best, and distinguishing more groups does not result in stable results. In the data at t_2 two groups of students can be distinguished. Inspection of the attributes of the students shows that these two groups correspond exactly with one of the opportunity variables, program. The groups consist of those students in one of the two study programs: the regular four-year program, or the short two-year program for students with previous training.

3.2 p_2

The module p_2 (version 2.00) is designed for the analysis of binary social network data with actor and/or dyadic covariates. The program carries out the estimation of a random effects model with the dyadic ties as the dependent variable according to the Iterative Generalized Least Squares algorithm for nonlinear multilevel models as described by Van Duijn (1995). For more detailed information the reader is referred to Van Duijn (1995) and Lazega and Van Duijn (1998).

The p_2 model is a type of logistic regression model for the ties in a network, to which a reciprocity effect is added as well as random sender and receiver effects (representing differential activity and popularity, respectively). In that respect it can be regarded as an extension of the well-known p_1 model (Holland and Leinhardt, 1981), where the actor parameters are replaced by random effects and actor and dyadic attributes can be included. Fitting the p_1 model in StOCNET is discussed in Section 5.

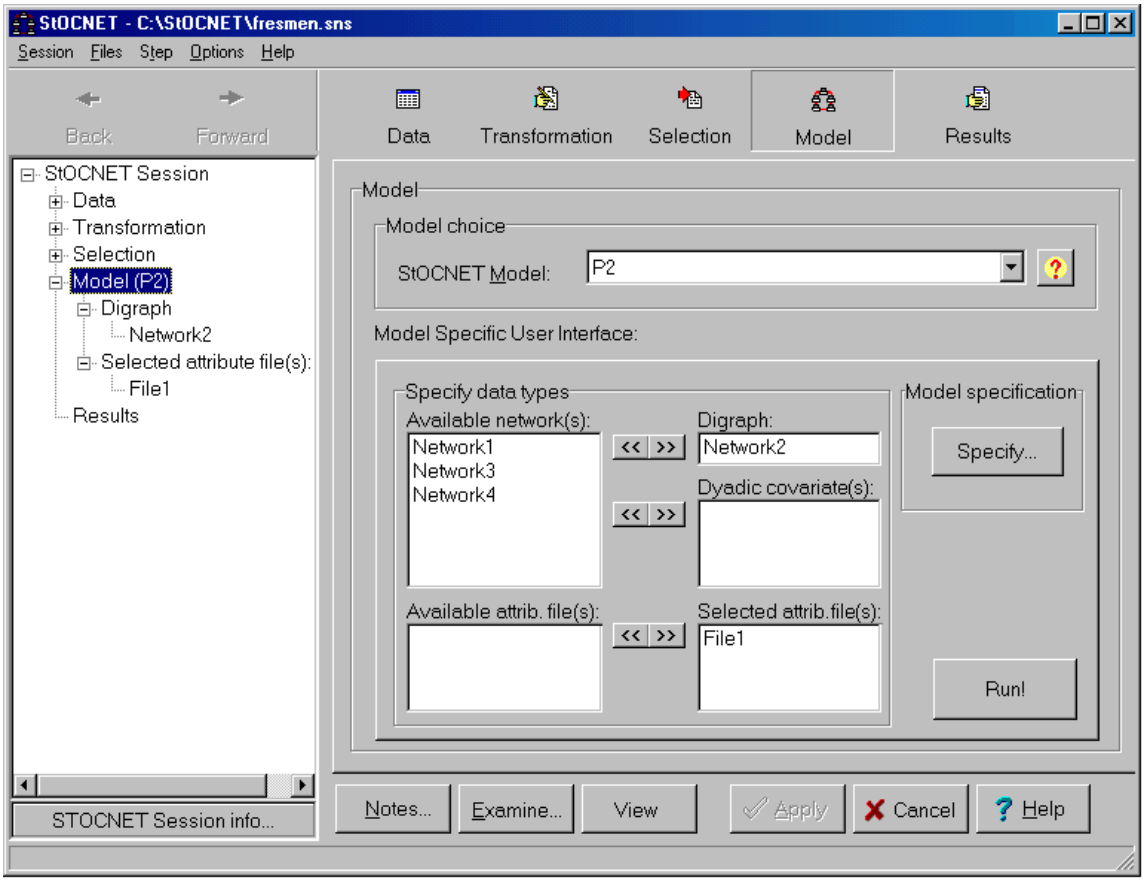

Figure 3. p_2 – Model-specific user interface.

In Figure 3 the model-specific user interface for p_2 is shown. The options that have to be specified by the user are the network and actor attribute data, and the model parameters, that is, the effects to be included in the model. There are four different kinds of effects, density, reciprocity, sender, and receiver effects, which are all based on the covariates.

University freshmen

The data observed at the second time point t_2 are analyzed with the p_2 model. Only the actor attributes program, smoking, and gender are included. The results are presented in Table 2.

Table 2: Parameters estimates for the university freshmen data at observation time t_2, obtained with the program p_2 (only significant effects).

	Parameter	Est.	(s.e.)
Sender	Variance s^2_A	0.68	-0.19
Receiver	Variance s^2_B	1.21	-0.27
Sender-receiver	Covariance s_{AB}	-0.09	-0.18
Density	μ	-4.21	-0.38
	Similarity program	1.9	-0.26
	Similarity gender	1.16	-0.22
Reciprocity	ρ	1.12	-0.3

In the p_2 analysis no significant sender and receiver effects are found. Similarity with respect to program and gender both have a significant and positive effect on density (i.e., there are more relations between students in the same program, between male students, and between female students). There is a general reciprocity effect, but this is not differentiated according to similarity variables. The receiver variance is much larger than the sender variance, due to the missing reports of 13 of the 38 students, whereas those missing students did receive choices of the others.

3.3 SIENA

The module SIENA (Simulation Investigation for Empirical Network Analysis; version 1.97) is a program that carries out the statistical estimation of models for the evolution of social networks according to the dynamic actor-oriented model of Snijders (2001). For more detailed information on the program or on stochastic actor-oriented models, the reader is referred to Snijders (2001) and to the user's manual of SIENA (Snijders and Huisman, 2002).

Stochastic actor-oriented models are used to model longitudinal network data. The dependent variable is the evolving relation network, represented by repeated measurements of a directed graph. The network evolution is modeled as the consequence of actors initiating new relations or withdrawing existing relations such that a more rewarding configuration for the actor in the network emerges. This goal is modeled in a so-called objective function the actors try to maximize. The models are continuous-time Markov chains that are implemented as simulation models.

In Figure 4 the model-specific user interface for SIENA is shown. The model specifications are presented in four groups: specification of network types (digraphs and dyadic covariates), actor attributes (varying and non-varying covariates, and times of composition change), estimation options (model specification and advanced estimation options), and simulation options (to simulate the network evolution without parameter estimation).

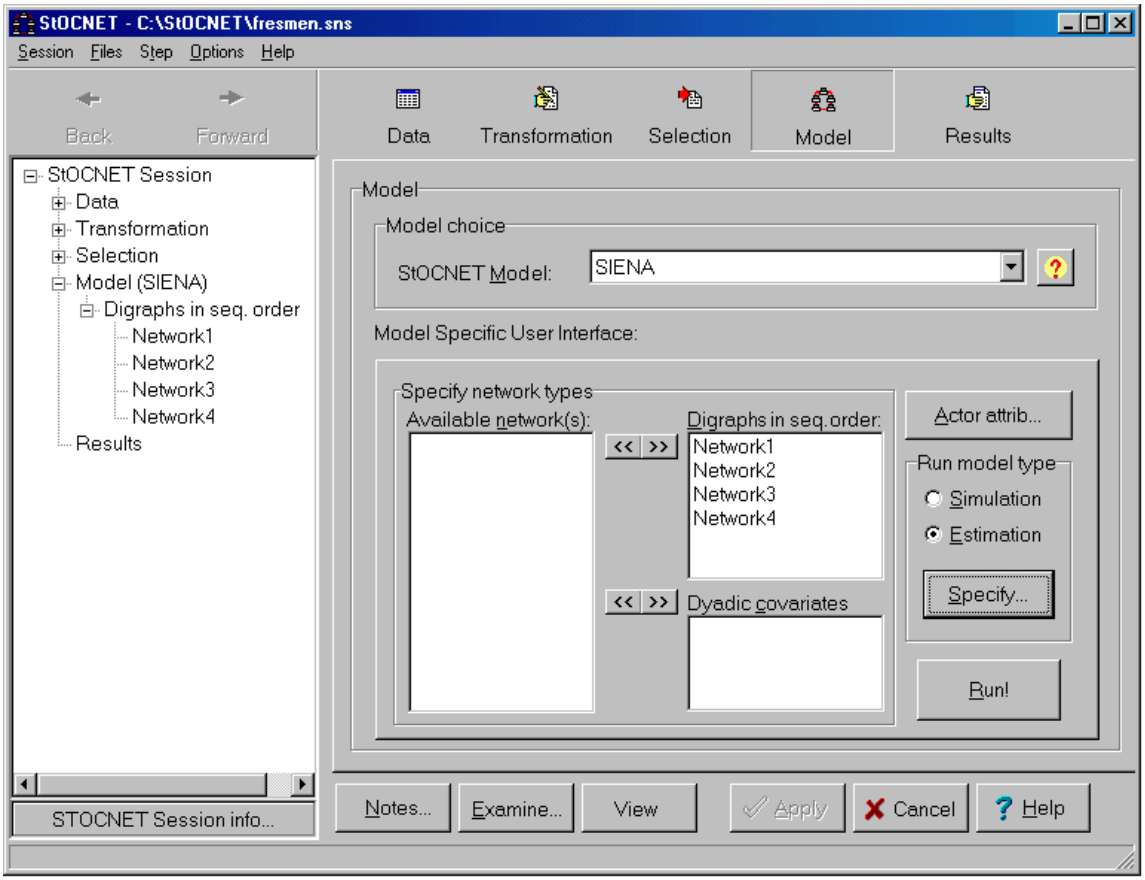

Figure 4. SIENA - Model-specific user interface

University freshmen

Data at four observation times (t_1 to t_4) are used to model the network evolution with the program SIENA[8]. The effects included in the actors' objective functions are reciprocity, balance, and popularity (network effects), and program, smoking behavior, and gender (actor attributes). For the three attributes dissimilarity effects are calculated, that is, the preference for dissimilar others. Four

[8] For a more detailed discussion of the results see Van Duijn et al., 2003

different models are estimated: for the evolution from t_1 to t_2, t_2 to t_3, t_3 to t_4, and the complete period t_1 to t_4. The results (parameter estimates and standard errors) are presented in Table 3.

The rate parameters in table 3 shows that in each of the three periods the actors made about 5, 3, and 5 relationship changes on average, respectively. In each period the actors have a preference for establishing reciprocated relations (large, positive reciprocity effects) and balanced network configurations (closed networks). Only in the last period the actors show a preference for initiating relations with popular alters (i.e., alters with large in-degrees). The proximity variables program and smoking, and the visible attribute gender, are only important in the early stages of the evolutionary process. In the first period, students initiate new relations with others in the same study program as do smokers with other smokers. Also, women tend to choose other women and men other men (negative dissimilarities).

From the fourth model it follows that the attributes program and gender are important effects to model network changes for the complete time period, although they are only significant in the early stages of the evolutionary process. The popularity effect is also an important effect for the complete time period, whereas it is only significant in model 3.

Table 3: Parameters for models estimated using observations t_1 to t_4 of the freshmen data. Only the parameters for which the *t*-value (estimate divided by standard error) is larger than 1.5 are depicted.

	Model 1: $t_1 - t_2$		Model 2: $t_2 - t_3$		Model 3: $t_3 - t_4$		Model 4: $t_1 - t_4$	
Effect	Est.	(s.e.)	Est.	(s.e.)	Est.	(s.e.)	Est.	(s.e.)
Rate (period 1)	5.26						7.01	
Rate (period 2)			2.96				3.06	
Rate (period 3)					5.30		5.28	
Density	-		-1.61	(0.48)	-2.17	(0.84)	-1.52	(0.56)
Reciprocity	2.61	(1.04)	3.51	(1.63)	3.07	(0.98)	2.92	(0.58)
Balance	9.25	(3.95)	6.62	(3.04)	9.18	(2.74)	7.25	(2.10)
Popularity	-		-		6.55	(2.05)	7.08	(1.23)
Program – dissimilarity	-1.10	(0.19)	-		-		-0.79	(0.13)
Smoking – dissimilarity	-0.37	(0.22)	-		-		-	
Gender – dissimilarity	-0.60	(0.22)	-		-		-0.40	(0.14)

3.4 p^* SIENA

Another application of the SIENA module is the estimation of the exponential random graph model, also called the p^* model (Frank and Strauss, 1986; Wasserman and Pattison, 1996), using Markov chain Monte Carlo (MCMC) methods described in Snijders (2002a). For more detailed information about the estimating the p^* model with SIENA the reader is referred to these articles and to the SIENA user's manual (Snijders and Huisman, 2002).

An exponential random graph model, that is, p^* model, is estimated if only one observation moment is specified in the SIENA program. The module carries out MCMC estimation for this model. If the algorithm works properly, the computed estimates are approximations of the maximum likelihood estimates. However, it is discussed in Snijders (2002a) that there are problems for estimating parameters of the likelihood distribution, and for many data sets it is impossible to achieve satisfactory estimates-perhaps it is next to impossible with any method. To use p^* SIENA it is advisable to first read Snijders (2002a). SIENA also gives maximum pseudolikelihood estimates (cf. Frank and Strauss, 1986; Wasserman and Pattison, 1996).

University freshmen

The data observed at t_2, the first occurrence of the network, are analyzed with the program SIENA. The results are presented in Table 4. The estimated network effects are number of ties (density), reciprocity and transitive triplets. Although the models show the same general picture (also found in the longitudinal analysis), Table 4 shows some differences between the two estimation procedures. The MCMC method implemented in SIENA is recommended, because the properties of the pseudolikelihood estimators are unknown. It should be noted, however, that the convergence of the SIENA p^* model was doubtful. When the transitivity effect was deleted from the model, good convergence was obtained.

Table 4: Parameter estimates for the university freshmen data at observation time t_2, obtained with the program SIENA (MCMC and pseudolikelihood).

	MCMC		pseudolikelihood	
Effect	Est.	(s.e.)	Est.	(s.e.)
Number of ties	-3.61	(0.96)	-5.09	(0.39)
Reciprocity	3.99	(0.37)	1.97	(0.29)
Transitive triplets	0.17	(0.04)	0.57	(0.05)
Program – dissimilarity	-0.75	(0.25)	-1.10	(0.26)
Smoking – dissimilarity	-0.04	(0.03)	-0.14	(0.04)
Gender – dissimilarity	-0.41	(0.16)	-0.80	(0.22)

3.5 ULTRAS

The module ULTRAS (version 1.1) aims at estimating latent transitive structures in social networks. The program estimates latent structures expressed by ultrametrics as presented by Schweinberger and Snijders (2003) and identifies and describes groups according to this latent structure. For more detailed information the reader is referred to Schweinberger and Snijders (2003) and to the user's manual of ULTRAS (Schweinberger, 2002).

Transitive structures can be used to identify close-knit subsets of actors in large social networks, which may contain even hundreds of actors. Latent transitive structures can be expressed by ultrametrics, measuring distances between actors based on triads. The module ULTRAS estimates ultrametrics, given one observed network, under the assumption that the probability of a tie depends

on the ultrametric distance between the two actors. The observed network may be generated by one, two, or even more ultrametrics. The program can handle dichotomous, discrete, as well as continuous network data. Maximum Likelihood Estimation is done using a non-greedy optimization algorithm, and Bayesian inference with uniform priors is implemented using hybrid MCMC methods (Schweinberger and Snijders, 2003).

In Figure 5 the model-specific user interface for ULTRAS is shown. To specify the model, the user has to determine the maximum value the ultrametric distance between any two actors may take on, and to indicate how the network ties are distributed (Bernoulli, Poisson, or Gaussian). To estimate the ultrametrics, either a Maximum Likelihood or Bayesian procedure can be used. Clicking the Specify-button gives the possibility to specify certain basic ingredients to the algorithm and output options.

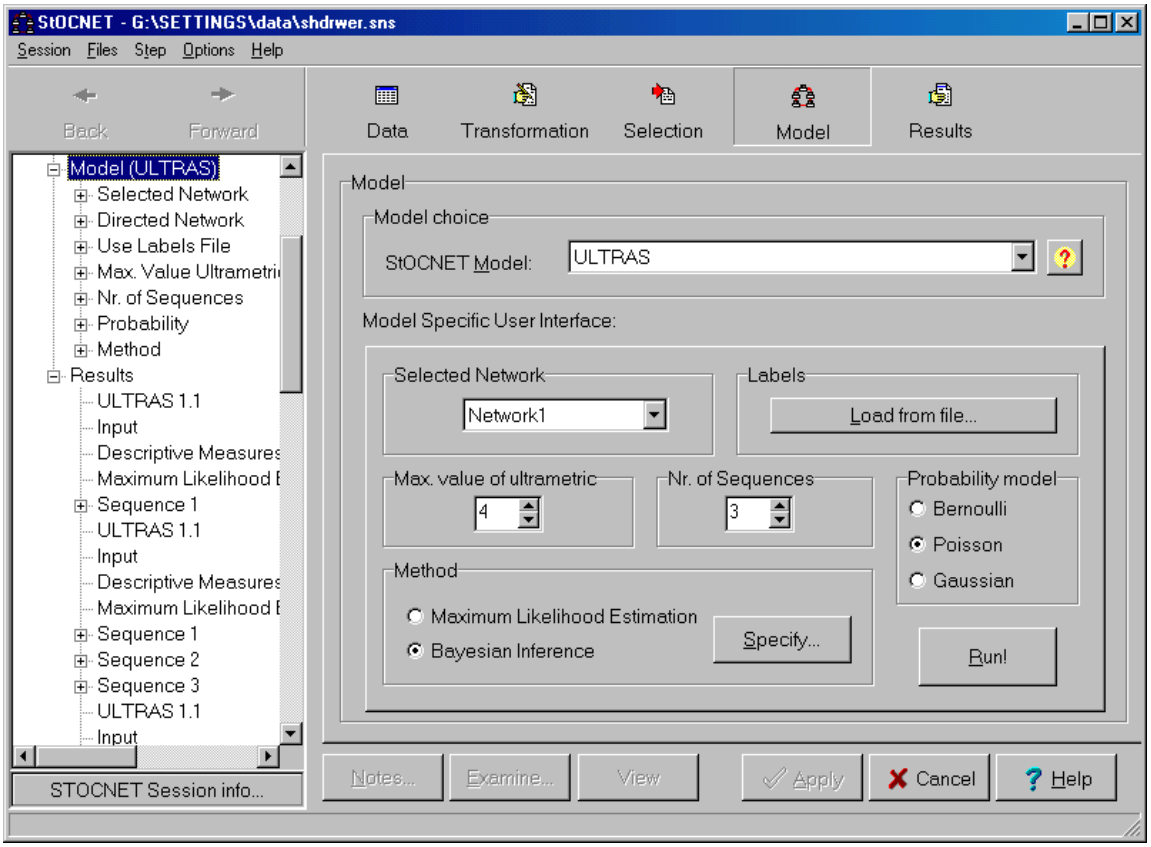

Figure 5. ULTRAS – Model-specific user interface.

University freshmen

The data observed at the second time point t2 are analyzed with ULTRAS. Since the outcome spaces of the tie variables are discrete, the Poisson probability model is used. Maximum likelihood estimation is executed, assuming that one ultrametric has generated the observed network. The maximum log likelihood value is found to be –538.29. The main results are presented in Table 5 on the next page.

Table 5: ML estimates and posterior means of theta for the university freshmen data at observation time t_2, obtained with the program ULTRAS.

	MLE		Bayesian approach	
Parameter	Est.	(s.e.)	Posterior mean	Posterior (s.e.)
theta(1)	2.86	(0.19)	2.34	(0.40)
theta(2)	1.17	(0.07)	1.78	(0.15)
theta(3)	0.65	(0.10)	0.84	(0.09)

The estimates of theta(h) have to be interpreted as the estimated tie value, given that the ultrametric distance between the actors takes the value h. The ultrametric which maximizes the log likelihood function (not shown) reveals that, given distance h = 2, there is one large group and one small group. The ML-ultrametric can also be represented as an ultrametric tree, similar to a dendrogram in cluster analysis.

Executing Bayesian inference, the average log likelihood value over the ultrametrics sampled from the posterior distribution is found to be -572.60. The posterior standard deviations (and other output not presented here) indicate that the model is uncertain about the latent structures in the network. This could be due to the small network size and the many missing values. The Bayesian procedure shows that actors 18 and 32 may decrease the global model fit. When these actors are excluded from the analysis, the average log likelihood changes to -526.41, improving the model fit.

3.6 ZO

ZO (Zero-One; version 2.3) is a program that calculates the probability distribution of any statistic of random graphs with given degrees and random digraphs with given in- and out-degrees. In addition it is possible to request a given number of mutual dyads and/or a connected graph. ZO carries out simulation and/or enumeration analysis of the graphs according to the algorithms of Snijders (1991) and Molloy and Reed (1995). For more detailed information on the program or probability distributions of statistics of random (di)graphs, the reader is referred to Snijders (1991) and Molloy and Reed (1995), and the user's manual of ZO (Snijders, 2002b).

ZO determines the distribution of statistics for general (rectangular) random 0-1 matrices with given row and column sums, including matrices with structural zeros (i.e., the restriction that a given set of entries is equal to 0). The distribution of the random 0-1 matrices is uniform, that is, each matrix satisfying the restrictions has the same probability of occurrence. The results include p-values that can be used for testing reciprocity or transitivity while controlling for the in- and out-degrees. For very small matrices (up to 8-12 rows and columns) this can be done by enumerating all matrices satisfying these constraints; the simulation method is more generally applicable.

In Figure 6 the model-specific user interface for ZO is presented. The user has to specify the following: 1. network data (adjacency matrix or separate file containing only row and column sums), 2. type of matrix to be analyzed, 3. the run-model type (simulation or enumeration), and 4. options

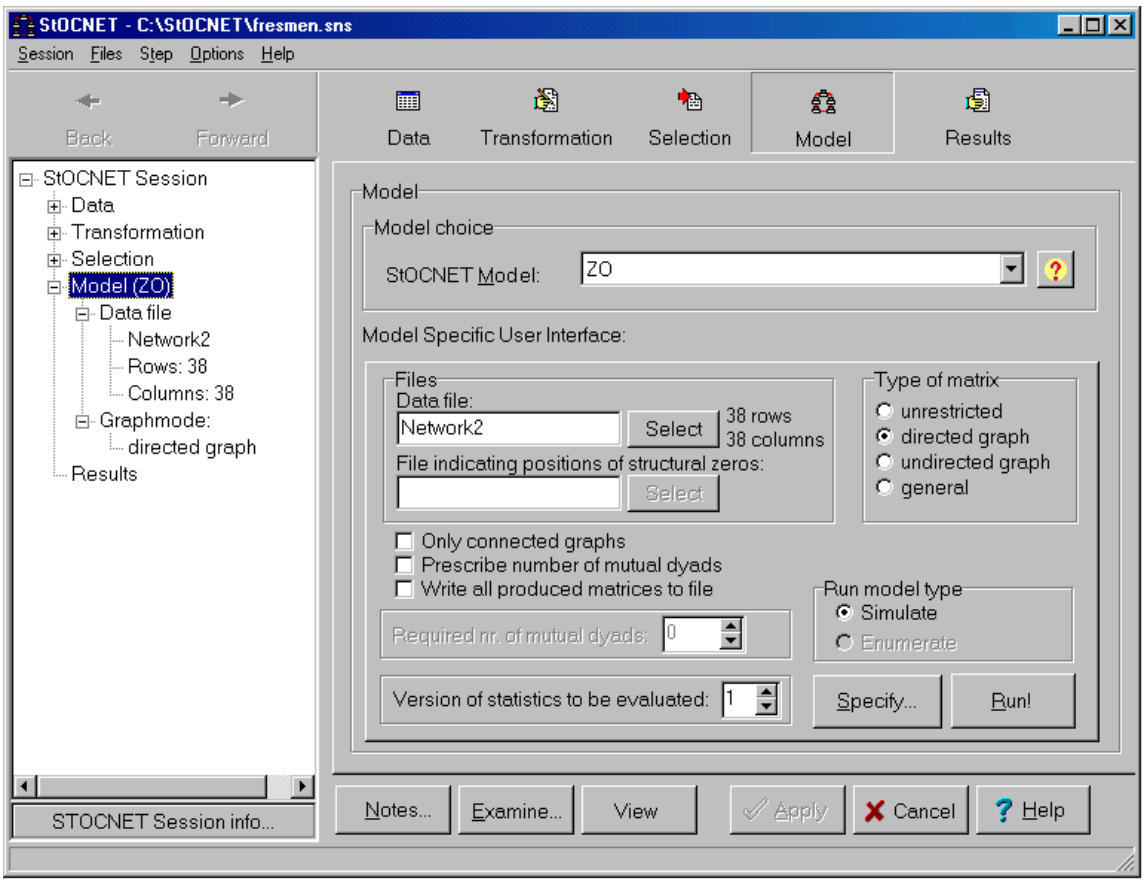

Figure 6. ZO — Model-specific user interface.

that depend on previous choices (e.g., specifying that the graphs that are generated by ZO should be connected – only for graph-type matrices, or specifying the number of mutual dyads – only for digraps).

University freshmen

The data observed at the second time point t_2 are analyzed with the ZO model. Part of the ZO results are presented in Figure 7 on the next page.

A test for reciprocity is carried out on the freshmen data by testing the number of mutual dyads M in the $U \mid X_{i+}, X_{+i}$ distribution (see Wasserman and Faust, Ch. 13). The observed number of mutual dyads in the freshmen data is 136. With 10,000 simulation runs, a probability distribution of the mutual dyads was calculated (presented in Figure 5). The observed number of 136 is so high under the null distribution, that such high values did not even occur once in 10,000 simulations (the maximum number was 124). It can be concluded that there is a very significant tendency toward reciprocity, given the in- and out-degrees.

In the same way a tendency towards transitivity is tested; null distributions will be the $U \mid X_{i+}, X_{+i}$, M distribution, with $M = 136$ (because the observed value of M is very unlikely giving the $U \mid X_{i+}, X_{+i}$ distribution, the number failed attempts will be large and therefore the number of simulations was reduced to 1000 to make it less time-consuming). The observed transitivity is 0.87, which is

larger than the maximum value found in the simulations (concentrating round 0.85, variance 0.08), indicating a strong significant tendency towards transitivity, controlling for in- and out-degrees and the number of mutual dyads.

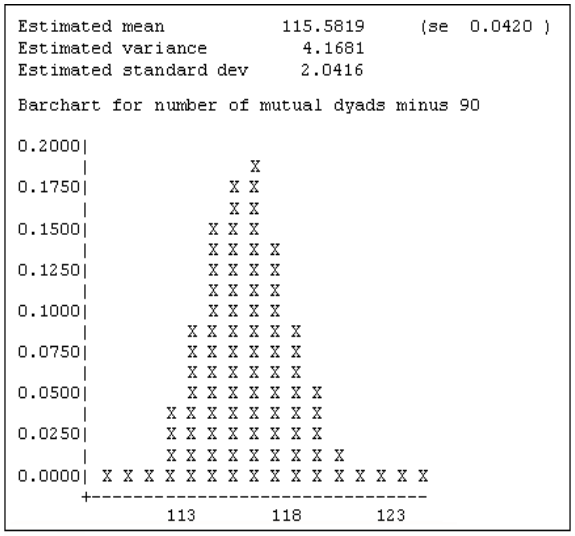

Figure 7. Part of the ZO output.

4. DESCRIPTIVE STATISTICS: EXAMINE

In four of the five steps of a StOCNET-session, the user has the opportunity to examine the data that are available up to and including the functionalities of the current step. After specification of the relevant options in each step-specific interface, clicking the *Examine-button* results in some descriptive analyses of the network and attribute data. The Examine-button is active in the steps Data definition, Transformation, Selection, and Model Specification, but not in the last step, Results.

In every step, clicking the Examine-button gives descriptives of all available network and attribute data (i.e., all network files and all attributes in all attribute files). The only exception is the fourth step (specification of a statistical model), where only those data files are analyzed that are specified in that step. Each time the specifications are changed in some session-step, for example, when the data are recoded (step 2) or when a different set of actors is selected (step 3), descriptives of the 'new' data sets are presented.

The following network descriptives are available in the current version of StOCNET (some statistics are only available for symmetric and/or dichotomous networks; see the StOCNET user's manual for more details):

Step 1. Relation count and dyad count.

Step 2. Missing values, density, degrees, degree variances, index of heterogeneity, dyad census, degree of reciprocity, triad count, (normalized) degree of transitivity, triad census, degree of segmentation, number of isolates and number of weak components.

Step 3. Same descriptives as in step 2.

Step 4. For the program p_2, clicking the Examine-button results in fitting the p_1 model (Holland and Leinhardt, 1981). For the program SIENA, clicking the Examine-button results in tables containing change statistics (change in arcs, dyads, and triplets). For the other three programs (BLOCKS, Ultras, and ZO) there are no descriptive analyses available.

It should be noted that apart from the descriptive statistics that are generated by the examine-function, the output of some of the available models also contains some descriptive statistics, which are too important to miss (according to the contributors of the programs).

5. PLANNED ACTIVITIES

Some new StOCNET options and functionalities, as well as some new modules will become available in future versions of the program. The planned activities are presented in this section.

- Modules PALNET and PACNET: Pattison and Wasserman (1995) and Pattison, Wasserman, Robins, and Kanfer (2000) present methods for the construction and fitting of structural models for local (i.e., ego-centered) and complete social networks, respectively.

  The methods proposed by Pattison and Wasserman (1995) give researchers a tool to adequately summarize social networks with different types of ties. They define partial algebraic structures from the collection of network paths that have a focal individual as their source, and present a method for deriving algebraic representations from local network data. The statistical criteria used in the method are based on permutation distributions. The methods are implemented in the program PALNET with which partial algebras can be constructed from network paths with a fixed, maximum length.

  The purpose of the program PACNET is to construct a partial algebra for a complete network, using statistical criteria based on conditional uniform random graph distributions. Both PALNET and PACNET are written in C and still only available from the authors. However, the programs are in the process of being implemented in the StOCNET system and thus will become available to a wider audience.

In order to provide a new platform to make statistical programs available to a wider audience, the StOCNET system was set up in such a way that new modules be implemented with as little effort as possible. New contributions can be implemented as executables or as DLLs, and their source codes are allowed to be written in a large variety of programming languages (e.g., Delphi, C, C^{++}).

The platform with its common data structure and user interface is provided by the StOCNET system, and the programs containing the statistical methods are treated as black boxes. All procedures will have similar interfaces and the contributors therefore only need to provide information with respect to data input, data representation, data output, parameter restrictions and so forth. Moreover, the procedures should have some general properties:

- proper documentation,
- the status of the calculations sent to the screen,

- user break possibility,
- proper error handling and error messages through error or log files,
- correct memory handling and allocation, and
- an ASCII input file for model definition and parameter input.

News about StOCNET can be found at the StOCNET website at http://stat.gamma.rug.nl/stocnet/. Here, new versions of the program and the corresponding documentation will be available for downloading. Also a brief history of the project is given, and of its goals and team members. Instructions for new contributors (including a questionnaire to be filled-in in order to facilitate inclusion of potential contributions) can be found as well, together with a list of potential contributors, whose programs are candidates for implementation in StOCNET.

REFERENCES

Batagelj, V. and A. Mrvar. 2002. *Pajek. Version 0.84.* Ljubljana: University of Ljubljana. http://vlado.fmf.uni-lj.si/pub/networks/pajek/.

Boer, P., M. Huisman, T.A.B. Snijders, and E.P.H. Zeggelink. 2002. *StOCNET: An open software system for the advanced statistical analysis of social networks. Version 1.3*. Groningen: *Pro*GAMMA/ICS. http://stat.gamma.rug.nl/stocnet/.

Borgatti, S.P., M.G. Everett, and L.C. Freeman. 1999. *UCINET V for Windows: Software for social network analysis*. Natick: Analytic Technologies. http://www.analytictech.com/ucinet_5_description.htm.

Burt, R.S. 1991. *STRUCTURE. A general purpose network analysis program providing sociometric indices, cliques, structural and role equivalence, density tables, contagion, autonomy, power and equilibria in multiple network systems. Version 4.2.* New York: Colombia University.

Cyram. 2002. *Cyram NetMiner. Version 1.2.0.* Seoul: Cyram Co., Ltd. http://www.netminer.com .

Frank, O. and D. Strauss. 1986. Markov graphs. *Journal of the American Statistical Association* , 81: 832-842.

Holland, P.W. and S. Leinhardt. 1981. An exponential family of probability distributions for directed graphs. *Journal of the American Statistical Association*, 76: 33-50.

Huisman, M. and M.A.J. Van Duijn. 2002. *StOCNET in development: An update.* Paper presented at the International Sunbelt Social Network Conference XXII, New Orleans, USA. February 13-17, 2002. http://stat.gamma.rug.nl/stocnet/.

Huisman, M. and M.A.J. Van Duijn. 2003. Software for social network analysis. To appear in P.J. Carrington, J. Scott, and S. Wasserman (Eds.) *Models and methods in social network analysis.* New York: Cambridge University Press. Preprints are available from the authors

Huisman, M. and T.A.B. Snijders. 2003. *Statistical analysis of longitudinal network data with changing composition.* [submitted]

Lazega, E. and M.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.

Molloy, M. & B. Reed. 1995. A critical point for random graphs with a given degree sequence. *Random Structures and Algorithms*, 6, 161-179.

Nowicki, K. and T.A.B. Snijders. 2001. Estimation and prediction for stochastic blockstructures. *Journal of the American Statistical Association*, 96: 1077-1087.

Pattison, P. and S. Wasserman. 1995. Constructing algebraic models for local social networks using statistical methods. *Journal of Mathematical Psychology*, 39: 57-72.

Pattison, P., S. Wasserman, G. Robbins, and A. Kanfer. 2000. Statistical evaluation of algebraic constraints for social networks. *Journal of Mathematical Psychology*, 44: 536-568.

Richards, W.D. and A.J. Seary. 1993. *FATCAT. Version 4.2*. Burnaby: Simon Fraser University. http://www.sfu.ca/~richards/.

Richards, W.D. and A.J. Seary. 2002. *MultiNet. Version 4.0 for Windows*. Burnaby: Simon Fraser University. http://www.sfu.ca/~richards/.

Schweinberger, M. 2002. *Manual for ULTRAS. Version 1.1.* Groningen: ICS/Dept. of Statistics & Measurement Theory, University of Groningen.

Schweinberger, M. and T.A.B. Snijders. 2003. Settings in social networks: Represented by latent transitive structures. [submitted]

Sprenger, C.J.A. and F.N. Stokman. 1989. *GRADAP 2. GRAph Definition and Analysis Package* . Groningen: *Pro*GAMMA.

Snijders, T.A.B. 1991. Enumeration and simulation models for 0-1 matrices with given marginals. *Psychometrika*, 56: 397-417.

Snijders, T.A.B. 2001. The statistical evaluation of social network dynamics. In M.E. Sobel & M.P.Becker (Eds.) *Sociological Methodology*. (pp. 361-395) London: Basil Blackwell.

Snijders, T.A.B. 2002a. Markov Chain Monte Carlo estimation of exponential random graph models. *Journal of Social Structure*, 3 (2). http://www2.heinz.cmu.edu/project/INSNA/joss/index1.html

Snijders, T.A.B. 2002b. *Manual for ZO version 2.3*. Groningen: ICS/Dept. of Statistics & Measurement Theory, University of Groningen. http://stat.gamma.rug.nl/stocnet/ .

Snijders, T.A.B. and M. Huisman. 2002. *Manual for SIENA. Version 1.95*. Groningen: ICS/Statistics & Measurement Theory, University of Groningen. http://stat.gamma.rug.nl/stocnet/ .

Snijders, T.A.B. and K. Nowicki. 2001. *Manual for BLOCKS. Version 1.53*. Groningen: ICS/Statistics & Measurement Theory, University of Groningen. http://stat.gamma.rug.nl/stocnet/.

Snijders, T.A.B. and M.A.J. van Duijn. 2002. Conditional maximum likelihood estimation under various specifications of exponential random graph models. In Jan Hagberg (Ed.), *Contributions to social network analysis, information theory, and other topics in statistics; A festschrift in honour of Ove Frank* (pp. 117-134). University of Stockholm, Department of Statistics.

Van Duijn, M.A.J. 1995. Estimation of a random effects model for directed graphs. In: *SSS'95. Symposium Statistische Software, nr. 7. Toeval zit overal: programmatuur voor random-coëfficiënt modellen*, T.A.B. Snijders, ed., 113-131. Groningen: *Pro*GAMMA.

Van Duijn, M.A.J., E.P.H. Zeggelink, M. Huisman, F.N. Stokman, and F. Wasseur. 2003. Evolution of sociology freshmen into a friendship network. *Journal of Mathematical Sociology*. [in press]

Wasserman, S. and K. Faust. 1994. *Social network analysis: Methods and applications*. Cambridge: Cambridge University Press.

Wasserman, S. and P. Pattison. 1996. Logit models and logistic regression for social networks: I. An introduction to Markov graphs and p^*. *Psychometrika*, 61: 401-425.

Zeggelink, E.P.H., T.A.B. Snijders, and P. Boer. 2000. *StOCNET in development*. Paper presented at the International Sunbelt Social Network Conference XX, Vancouver, Canada. April 13-16, 2000.

CONNECTIONS 25(1): 27-35

A Note on Network Sampling in Drug Abuse Research

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In this article we discuss a network sampling design that can be applied in drug abuse research at the community level. At this level often some partial sampling frame such as the register of a drug aid agency is available. This partial sampling frame can be used as the start of a network sample. Each selected registered drug abuser mentions his relationships with other drug abusers, and from those newly mentioned drug abusers who are not registered a second probability sample is drawn. Using this network sampling design the mean contact rates between clients, between clients and non registered drug abusers and between non registered drug abusers can be estimated despite the unknown total number of drug abusers. The design is illustrated by an analysis of the network data of the Heerlen Drug Monitoring System.

INTRODUCTION

In studies of drug abuse populations such as heroin, cocaine and methadone users, standard probability sampling designs are often impractical due to imperfect sampling frames which decrease the possibilities of formal inference (Van Meter, 1992). Some practical problems are the unknown size of the population, the geographical clustering of groups of users, the identification of the target group, the establishment of contact, etc. To cope with these problems a frequently applied data collection procedure is a link-tracing procedure. A link-tracing procedure is a data collection method that follows social relations in the study population by using the contact patterns that exist between the drug abusers. The classical link-tracing procedure is the snowball sampling technique (Goodman, 1961), in which persons are asked to mention a fixed number k of other persons, who, in turn,

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are selected for extending the initial sample by mentioning *k* other persons, and so on .... Some other link-tracing techniques are the snowball design of Frank (1977a), the random walk design of Klovdahl (1989), and the adaptive cluster sampling design of Thompson (1991). An overview of link-tracing data collection techniques is given in Spreen (1992).

In drug abuse studies link-tracing methods are mainly used as a tool to find a substantial amount of respondents in order to describe the population in terms of individual characteristics. Standard nonprobability sampling designs such as targeted sampling (Watters & Biernacki, 1989) have been elaborated with the intention to mirror an initial simple random sample from the total population. Subsequently the link-tracing procedure starts from this initial sample. Data obtained by link-tracing sampling methods can also be used to describe the population in terms of structural characteristics (Snijders & Frank, 2000; Thompson & Frank, 2000). Until now the analysis of link-tracing data from a structural perspective has been largely ignored in drug abuse studies.

The purpose of this article is to introduce a network sampling design that can be used in community-based drug abuse studies. Often some registers of aid agencies are available from which to start a network sample with an initial probability sample. We will illustrate this design with an analysis of the network data from the Heerlen Drug Monitoring System (Coumans, et al., 2000). The tentative question we explore in this article is whether community oriented prevention/intervention strategies could be applied using the networks of the clients of the aid agencies. Therefore estimators are needed for the mean number of contacts within and between the clients of the aid agencies and those drug abusers who are not client. Another structural study of the client population only is discussed in Spreen & Coumans (2000). First some graph theoretical definitions and notation must be introduced.

Graph theoretical problem definition

We consider an undirected graph G with vertex set $V = \{1, 2, 3, ..., N\}$ and adjacency matrix $\mathbf{Y}$, representing a set of social actors and some relationship between them. The adjacency matrix is defined on the set V^2 of the ordered pairs of vertices; $Y_{ij} = 1$ if there is an edge between vertices i and j, and $Y_{ij} = 0$ otherwise ($Y_{ij} = 0$ for all i). Since the graph is undirected, $Y_{ij} = Y_{ji}$ for all i, j. Based on some binary auxiliary variable Z, vertex set V can be partitioned into two disjoint vertex subsets α and β ($\alpha \cap \beta = \varnothing$), i.e.

- $\alpha = \{i \in V \mid Z = 1\}$ with order N_α
- $\beta = \{u \in V \mid Z = 0\}$ with order N_β.

For the sake of clarity throughout the paper, vertices i and j refer to subset α; u and v to subset β.

Based on vertex sets α and β population graph G can be decomposed into three subgraphs:

1. subgraph G_α with arcs between the vertices of set α,
2. subgraph G_β with arcs between the vertices of set β, and
3. subgraph $G_{\alpha\beta} = G_{\beta\alpha}$ with arcs between the vertices of sets α and β.

Figure 1 is an illustration of population graph *G* with vertex set $V = \{1, 2, ..., 7\}$ of order $N = 7$ and size R = 10, i.e. *G* consists of *N* vertices and *R* arcs. Based on auxiliary variable *Z* vertex set *V* is partitioned into subset $\alpha = \{1,2,3,4\}$ and subset $\beta = \{5,6,7\}$.

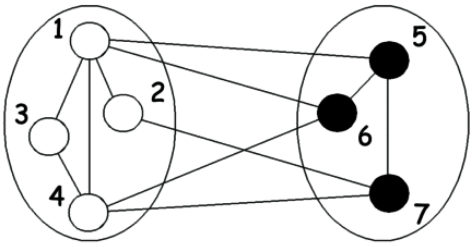

Figure 1 Population *G* with vertex set *V*

The number of relations between vertices of α, i.e. the size of subgraph G_α, is denoted

$$R_\alpha = \frac{1}{2}\sum_{i\in\alpha}\sum_{j\in\alpha} Y_{ij} \; ; \tag{1}$$

between the vertices of β, i.e. the size of subgraph G_β, is denoted

$$R_\beta = \frac{1}{2}\sum_{u\in\beta}\sum_{v\in\beta} Y_{uv} \; ; \tag{2}$$

and between vertices of α and β, i.e. the size of subgraph $G_{\alpha\beta} = G_{\beta\alpha}$ is denoted

$$R_{\alpha\beta} = R_{\beta\alpha} = \sum_{i\in\alpha}\sum_{u\in\beta} Y_{iu} \; . \tag{3}$$

In Figure 1 $R_\alpha = 4$, $R_\beta = 2$ and $R_{\alpha\beta} = R_{\beta\alpha} = 5$.

The mean number of relations for $i \in \alpha$ with other $j \in \alpha$ is

$$\mu_\alpha = \frac{2}{N_\alpha} R_\alpha \; ; \tag{4.a}$$

for $i \in \alpha$ with $u \in \beta$ is

$$\mu_{\alpha\beta} = \frac{1}{N_\alpha} R_{\alpha\beta} \; . \tag{4.b}$$

The mean number of relations for $u \in \beta$ with other $u \in \beta$ is

$$\mu_\beta = \frac{2}{N_\beta} R_\beta \; ; \tag{5.a}$$

for $u \in \beta$ with $j \in \alpha$ is

$$\mu_{\beta\alpha} = \frac{1}{N_\beta} R_{\beta\alpha} . \tag{5.b}$$

In Figure 1, $\mu_\alpha = \frac{4}{4}$, $\mu_\beta = \frac{2}{3}$, $\mu_{\alpha\beta} = \frac{5}{4}$ and $\mu_{\beta\alpha} = \frac{5}{3}$.

In Figure 1 we also observe a seemingly trivial relationship

$$\frac{\mu_{\alpha\beta}}{\mu_{\beta\alpha}} N_\alpha = N_\beta , \tag{6}$$

which can, however, be used to get an indication of the total number of vertices.

Sampling design and estimation

We consider a simple random sample S of n vertices from α. Each $i \in S$ indicates his relations in G. This implies that i mentions relations with other vertices $j \in \alpha$ and $u \in \beta$. The number of vertices vertex $i \in \alpha$ mentions in G_α is denoted $a_{i|\alpha}$. the number of vertices $i \in \alpha$ mentions in G_β is denoted $a_{i|\beta}$. The total number of relations the n selected vertices mention in G_α is denoted $R_\alpha(S)$; the total number of relations the n selected vertices mention with vertices $u \in \beta$ is denoted $R_{\alpha\beta}(S)$.

Define by $\beta(S)$ the set of newly mentioned $u \in \beta$ of order $N_\beta(S)$; a sample T of size m according to a known probability design is drawn from $\beta(S)$. Each $u \in T$ indicates his relations in G. This implies that u may mention relations with other vertices $i \in \alpha$ and $w \in \beta$. The number of vertices vertex $u \in \beta$ mentions in G_β is denoted $a_{u|\beta}$; the number of vertices $u \in \beta$ mentions in G_α is denoted $a_{u|\alpha}$. The total number of relations the m selected vertices mention in G_β is denoted $R_\beta(T)$; the total number of relations the m selected vertices mention with vertices $i \in \alpha$ is denoted $R_{\beta\alpha}(T)$.

To estimate the average number of contacts vertex $i \in \alpha$ has with other vertices $j \in \alpha$ the well-known graph total estimators (Frank, 1971, 1977a,b, 1978; Capobianco & Frank, 1982) can be applied, i.e.

$$\begin{aligned} \hat{\mu}_\alpha &= \frac{2}{N_\alpha} \hat{R}_\alpha \\ &= \frac{2}{N_\alpha} \left(\frac{1}{2} \sum_{i,j \in S} \frac{Y_{ij}}{\pi_{ij}} + \sum_{\substack{i \in S \\ j \in \alpha \setminus S}} \frac{Y_{ij}}{\pi_{ij}} \right) \end{aligned} \tag{7}$$

where

$$\pi_{ij} = 1 - \frac{\binom{N_\alpha - n}{2}}{\binom{N_\alpha}{2}} = 1 - \frac{(N_\alpha - n - 1)(N_\alpha - n)}{(N_\alpha - 1)N_\alpha}$$

An unbiased variance estimator is given by

$$\hat{Var}(\mu_a)=\left(\frac{2}{N_a}\right)^2\left(\frac{(q_4-q_2)}{(1-q_2)^2(1-2q_2+q_4)}R^2_\beta(S)+\frac{(q_3-q_4)}{(1-q_2)^2(1-2q_2+q_4)}Q(S)+\frac{(q_2-2q_3+q_4)}{(1-q_2)^2(1-2q_2+q_4)}R_a(S)\right) \quad (8)$$

where q_H is defined as the inclusion probability that H specified distinct vertices are in the complement $\overline{S}$ for $H = 2, 3, 4$, i.e.

$$q_H = \frac{\binom{N_\alpha - n}{H}}{\binom{N_\alpha}{H}} \quad (9)$$

and $Q(S) = \sum_{i=1}^{n}(Y_{i+})^2$ is the sum of squares of the degrees of the sampled vertices.

Estimator (7) can also be used to estimate the average number of vertices at distance 2 in G_α (see Spreen & Coumans, 2000).

The mean degree of relations $i \in \alpha$ has with vertices from β can be estimated by the conventional HT-estimator (Särndal et al, 1992), i.e.

$$\begin{aligned}\hat{\mu}_{\alpha\beta} &= \frac{1}{N_\alpha}\sum_{i\in S}\sum_{u\in\beta}\frac{Y_{iu}}{\pi_i} \\ &= \frac{R_{\alpha\beta}(S)}{n}\end{aligned} \quad (10)$$

where $\pi_i = n/N_\alpha$ and $\pi_{ij} = n(n-1)/N_\alpha(N_\alpha - 1)$

The variance estimator is defined as

$$\hat{Var}(\hat{\mu}_{\alpha\beta}) = \frac{1}{N_\alpha^2}\sum\sum_S\left(1-\left(\frac{\pi_i\pi_j}{\pi_{ij}}\right)\right)\frac{a_{i|\beta}}{\pi_i}\frac{a_{j|\beta}}{\pi_j} \quad (11)$$

To estimate the mean degree of relations $u \in \beta$ has with vertices from α and β, the unknown order of G_β will provide some problems because of the computation of design-based inclusion probabilities. A strategy to avoid these problems is to use the weighted sample mean as an estimator of N_β (Särndal *et al,* 1992), i.e. $\hat{N}_\beta = \sum_T(1/\pi_u)$, where N_β does not need to be known. We propose to approximate the inclusion probability of $u \in T$ by the relative frequency of the observed amount of relations with $i \in \alpha$. Denote the number of vertices $u \in T$ that have mentioned d vertices in G_α by M_d for $d = 1, 2, \ldots$ Then we may define

$$\pi_{u|d} = \frac{M_d}{m} \quad (12)$$

as the first-order inclusion probability of vertex $u \in \beta$.

To compute the second-order inclusion probability that vertices u and w are included in sample T we use the same approach. Denote the number of pairs of vertices with the same sum of degrees e by M_e for $e = 2, 3, \ldots$. The pairwise inclusion probability is defined as the relative frequency

$$\pi_{uw|e} = \frac{M_e}{(m-1)} \tag{13}$$

An estimator for the average number of relations $u \in \beta$ has with other $w \in \beta$ can be defined as

$$\hat{\mu}_\beta = \frac{2\hat{R}_\beta}{\hat{N}_\beta} = \frac{\sum_{u \in T} \frac{a_{u|\beta}}{\pi_u}}{\sum_{u \in T} \frac{1}{\pi_u}} \tag{14}$$

with variance estimator

$$\hat{Var}(\hat{\mu}_\beta) = \frac{1}{\hat{N}_\beta^2} \sum \sum_T \left(1 - \left(\frac{\pi_u \pi_w}{\pi_{uw}}\right)\right)\left(\frac{a_{u|\beta} - \hat{\mu}_\beta}{\pi_u}\right)\left(\frac{a_{w|\beta} - \hat{\mu}_\beta}{\pi_w}\right) \tag{15}$$

The average number of relations vertex $u \in \beta$ has with other vertices $i \in \alpha$ can be estimated by

$$\hat{\mu}_{\beta\alpha} = \frac{\hat{R}_{\beta\alpha}}{\hat{N}_\beta} = \frac{\sum_{u \in T} \frac{a_{u|\alpha}}{\pi_u}}{\sum_{u \in T} \frac{1}{\pi_u}} \tag{16}$$

with variance estimator

$$\hat{Var}(\hat{\mu}_{\beta\alpha}) = \frac{1}{\hat{N}_\beta^2} \sum \sum_T \left(1 - \left(\frac{\pi_u \pi_w}{\pi_{uw}}\right)\right)\left(\frac{a_{u|\alpha} - \hat{\mu}_{\beta\alpha}}{\pi_u}\right)\left(\frac{a_{w|\alpha} - \hat{\mu}_{\beta\alpha}}{\pi_w}\right) \tag{17}$$

ILLUSTRATION

As an illustration we analyse network data obtained from the Heerlen Drug Monitoring System (DMS). The purpose of the DMS is to describe the population of marginalised (nearly) daily users of opiates and/or other drugs (like cocaine) in terms of prevalence, patterns of use, problems (with use), social relationships and contacts with aid agencies. The system is based on three pillars, knowing:

1. information collected by a group of key informants who regularly report on phenomena and developments in and involving drug use;
2. ethnographic qualitative information about the natural context in which drug use takes place is collected by community field workers;

3. quantitative information about distributions and associations of various individual and relational characteristics in the population is collected by a network sample.

We focus on the contact rates between clients of the aid agencies, between clients and hard drug users that are not registered (hereafter called NR's), and between the NR's. From a health promotion perspective these patterns are relevant because they give an impression of the extent to which aid agencies could employ their clients for community prevention/ intervention strategies to reach also a substantial amount of NR's. Note that a relation between two drug abusers is viewed as a channel of communication.

In Heerlen *435* hard drug users were registered as a client of the aid agencies (at June 1 1999). Local experts assessed this figure to be a substantial part of the total unknown population. Because the purpose of the DMS is to draw on a regular base samples it was decided to use the client list, i.e. $\alpha = \{1, 2, ..., 435\}$, as an initial sampling frame. A simple random sample without replacement S of size $n = 39$ was drawn from $\alpha \subset V$ and for each $i \in S$ his relations with other users (alters) were observed and individual characteristics about the alters were collected. The criteria for the alters to be included in the sample were:

- respondent and alter must meet each other on a daily or regular base in Heerlen,
- respondent and alter must know each others sur- and family name,
- alter must know the respondent as a hard drug (heroin, cocaine, etc.) user.

The 39 selected clients mentioned 110 other clients with whom they reported 164 relations, i.e. $R_\alpha(S) = 164$. They also mention 81 drug abusers who were not registered, i.e. $N_\beta(S) = 81$, with whom they reported 93 relations, i.e. $R_{\alpha\beta}(S) = 93$.

The next step of the sample was to draw a random selection of these $N_\beta(S) = 81$ NR's. Due to all kinds of practical problems, we managed a random selection of m=18. These 18 non registered drug abusers mentioned 66 other users who were client of the aid agencies with whom they reported 91 relations, i.e. $R_{\beta\alpha}(T) = 91$. A total of 24 other NR's were mentioned by this group with whom they reported 26 relations, i.e. $R_\beta(T) = 24$.

From this sample we estimated the following averages (between brackets are the standard errors):

- an arbitrary client of the aid agencies has about *4* close relationships with other clients and about *2* with non registered hard drug users, i.e. $\hat{u}_\alpha = 4.18(0.33)$ and $\hat{u}_{\alpha\beta} = 2.38(0.38)$.
- an arbitrary non registered hard drug user has about *1* to *2* close relations with other non registered drug abusers and about *5* with clients, i.e. $\hat{u}_\beta = 1.67(1.20)$ and $\hat{u}_{\beta\alpha} = 4.81(1.58)$.

Thus both groups of drug abusers mentioned about *7* other drug abusers. The standard errors of the means of the non registered hard drug users are higher than those of the clients. A part of this difference is due to the small sample size of T. However because T was drawn randomly, the high standard errors give also an indication that the non registered hard drug users vary more in their contact rates with clients and NR's.

Clients mention about 64% in their own group while the NR's mention about 25% within their own group. From a community based health intervention strategy it is important to notice that the clients

have the tendency to have relations with other clients, although the non registered drug abusers also have a high proportion relationships with clients. Consequently to diffuse policy measures via communication channels of the clients only will be debatable, because they have the tendency to have contacts with other clients. However the non registered drug abusers could be 'easily' reached with some extra effort, as is shown by the average contact rates.

Another feature of this network design is that it is possible to get an indication of the total size of the drug abuse population in Heerlen. If we accept the assumption that each heroin abuser that is not registered knows at least *1* other heroin abuser that is a client of the aid agencies, then by using equation (1.6) we can define a simple ratio estimator for the total:

$$\hat{N} = N_{\alpha} + \frac{\hat{\mu}_{\alpha\beta}}{\hat{\mu}_{\beta\alpha}} N_{\alpha} = 435 + \frac{2.38}{4.81} 435 \approx 650$$

Local experts could not imagine that there was a large group of drug abusers in Heerlen not meeting this restrictive assumption. An advantage of this simple estimator is that in principle respondents do not need to give the identities of the people they mention. However, this implies that a random sample from the NR's must be replaced by a nonprobability sample. For monitoring purposes it will be a more easy and cheaper way to estimate the population of this difficult survey group.

REFERENCES

Capobianco, M. & Frank, O. (1982). Comparison of statistical graph-size estimators. *Journal of Statistical Planning and Inference*, 6, 87-97.

Coumans, A.M., Neve, R.J.M. & Mheen, H. van de. (2000). Het proces van marginalisering en verharding in de drugscene van Parkstad Limburg.(The process of marginalisation and hardening in the Heerlen drugscene). IVO, Rotterdam.

Frank, O. (1971). *Statistical inference in graphs*. FOA Repro, Stockholm.

Frank, O. (1977a) Survey sampling in graphs . *Journal of Statistical Planning and Inference*, 1, 235-264.

Frank, O. (1977b) Estimation of Graph Totals . *Scandinavian Journal of Statistics*, 4, 81-89.

Frank, O. (1978) Sampling and estimation in large social networks . *Social Networks*, 1, 91-101.

Goodman, L.A. (1961). Snowball sampling. *Annals of Mathematical Statistics*, 32, 148-170.

Klovdahl, A.S. (1989). Urban social networks: Some methodological problems and possibilities. In: M. Kochen(ed.), *The Small World*, Norwood, N.J.:Ablex.

Meter van, K.M. (1990). Methodological and design issues: Techniques for assessing the repesentatives of snowball sampling.In*: The collection and interpretation of data from hidden populations* , NIDA Research Monograph 98, Rockville.

Särndal, C. E., Swensson, B. & Wretman, J. (1992). Model assisted survey sampling. NewYork: Springer-Verlag.

Snijders, T.A.B. & Frank, O. (2000). Estimation of population characteristics from one-wave snowball samples in structured populations. *Paper presented at the Second International Workshop on Network Sampling, Maastricht (The Netherlands), March 2-4.*

Spreen, M.(1992) Rare populations, hidden populations, and Link-Tracing Designs: What and Why? *Bulletin de Methodologie Sociologique*, 36, 34-58.

Spreen, M. & Coumans. M. (2000) Network sampling hard drug users. A structural analysis of the clients of aid agencies in Heerlen. To appear: *Kwantitatieve Methoden.*

Thompson, S.K. (1991) Stratified adaptive cluster sampling, *Biometrika*,78, 2, 389-397.

Thompson, S.K & Frank, O. (2000). Model-based estimation with link-tracing sampling designs, *Survey Methodology*, 26, 1, 87-98.

Watters, J.K. & Biernacki, P. (1989). Targeted sampling: Options for the study of hidden populations. *Social Problems*, 36, 416-430.

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Visualizing Complexity in Networks: Seeing Both the Forest and the Trees

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Visualization of complex relational information has become increasingly important as complex data and computational power have become more available to social network researchers. Common sources of relational complexity include change over time, multiple relationships, network size, and network density. The most useful method for displaying complex data often depends upon the source of complexity and the nature of the information to be learned. In this paper, we explore the use of motion, especially for representation of change over time and relationship. Also, using data from a large Wall Street investment bank, we demonstrate several strategies to represent complex relational data in two-dimensions.

INTRODUCTION

Information visualization has become increasingly important as access to large amounts of data increased and the ability to analyze that data has improved. More work is needed to refine methods of conveying the information uncovered back to users who must make sense of the vast amount of information that is available to them. Within the field of computer science we have seen an

increased interest in information visualization in general (Chen, 1999; Ware, 2000). And within the area of social network analysis, new approaches to the visualization of relational data have emerged such as Pajek (Batagelj and Mrvar, 1998) KrackPlot (Krackhardt et al., 1994) MultiNet (Richards and Seary, 1999). For a complete discussion of the history of visualization in social network analysis see Freeman (2000). The interests of these two communities are converging. Computer scientists are ever more cognizant of the importance of agent interaction. Social network analysts make use of the increasingly complex information and computational resources availableto study dynamic, multi-relational networks made up of many actors. Complexity is introduced as the number of actors and relations modeled increases and the interaction between network size, density and change over time describes complex systems. In terms of computation, as systems become more complex they require more time, space or resources to solve. Similarly complex systems require that users expend more effort for visualization. The proper design of visual displays of complex data will lessen the burden on viewers trying to make sense of data and on researchers trying to communicate important features of the displayed data.

The most well considered approach to visual representation of network data uses two-dimensional static displays. This approach tovisualization uses the spatial positioning of nodes; characteristics of nodes such as color, shape, and size; and characteristics of edges such as texture and color to communicate as much information as possible within a single graph. While we have learned a lot about the importance of layout and characteristics of nodes and edges for communicating information in graphs, we see that there are limits to the amount of information that can be displayedin a static graph.

Three major sources of network complexity are data that describe longitudinal and multi-relational networks and data that describe networks made up of many actors with dense connections. Each of these advances in our ability to collect and analyse social network data calls for advances in network visualization as well. In this paper we discuss approaches using KrackPlot to address complexity resulting from changes over time and among relationships and complexity resulting from large-scale networks. While some aspects of complex networks can be communicated using current two-dimensional graph representations, other aspects require new visualization techniques. For example, motion is very useful for conveying information about changes in networks, especially when the user needs to convey change over time or over network relationships. There are some cases where motion is not the best option for displaying complex information. The usefulness of motion may be limited by the size and density of the graph, the nature of the change that occurs and the media for publication of the information. We organize the rest of the discussion by the source of complexity in the network, and explore motion as well as techniques using two-dimensional representations for displaying complex network data.

COMPLEXITY INTRODUCED BY NETWORK CHANGE

Motion is an obvious tool for displaying information about changes in networks over time, with the requisite warning that improperly applied, motion might obscure underlying phenomenon (Qin & Simon 1992a, 1992b and 1995). We havecompleted preliminary work (McGrath & Blythe, 2000) that suggests that viewers who are able to use motion to observe changes in graphs perceive those changes more quickly than those who are only able to switch between still representations of the

two time periods. Furthermore, we have shown that motion is particularly useful when used in conjunction with graph layout techniques that assign meaning to the positioning of nodes in Cartesian space (McGrath et al., 2001). In that case increased movement across representations highlights changes over time or across relationships. As expected, we found that motion is often useful for the efficient communication of network change. In response to these results, we have implemented a simple mechanism for displaying change across two graphs using motion in KrackPlot in order to allow users to employ motion easily.

Displaying Change with Motion in KrackPlot using MORPHING

The most recent version of KrackPlot includes a morphing function that allows users to take advantage of motion to display changes to the layout of a graph. The user first identifies an initial layout and then a second layout. Finally, the user designates the number of steps to be used to move from the first to the second layout. To use the morph function, users select "morph" from the top-level menu. Users may specify their first graph layout by selecting "first" while that layout is displayed on screen. Next the users can change the layout either by moving nodes and changing edges between nodes on the current graph interactively with the mouse or by loading a second version of the graph that contains the same nodes with different coordinates indicating their position on the screen. When the second layout is complete, the user selects "second" to identify the second layout. Now the "change" function will employ motion to display the change between the first and second layout.

The morphing function uses the shortest path between the first and second position of the each node in the graph. Any edges that change from the first to the second graph layout will change at the mid-point of the move from the first to second layout. The user can specify the number of steps between the first and second graph layout. The default number of steps between graphs is 50. If the number of steps is set to "1" the display flash between the first and second layout in "before and after" format. As the number of steps between the layouts increases, the motion appears to be more smooth. Currently, the morph function works best to convey changes in nodes' positions between the first and second layout. It does allow for adding and removing edges between the two layouts. It is more difficult to display changing nodes between the two layouts.

COMPLEXITY INTRODUCED BY NETWORK SIZE

A second source of complexity results from network size and density. Large network are difficult to visualize because of the sheer size and amount of information available. Similarly, dense networks contain a large amount of relational data that is difficult to visualize. There are several strategies that users might take to visualize and represent large networks in a meaningful way. The best approach to visualizing large data sets often depends upon characteristics of the network (such as density) and the nature of the information to be learned from the graph. Three approaches that are often useful are (1) visualizing subsets of a large graph, (2) partitioning a large graph and visualizing relationships among partitions, and (3) exploring structure interactively using simulated annealing and adjusting the energy function to address characteristics of the displayed network. We will demonstrate these three approaches using data from Friedman and Krackhardt (1997). The data describe friendship ties among 83 support staff people in a large Wall Street investment bank. Shapes indicate ethnicity: ellipses denote Southeast Asian staff; rectangles denote Indian staff;

diamonds denote European staff; staff of all other ethnicity are represented with no shape around them. Figure 1 shows the friendship ties among bank staff in a circle layout. The circle does give an idea of the density of the graph however, it communicates very little about the structure of the network. Starting with this baseline method of representation, we will demonstrate the three techniques listed above.

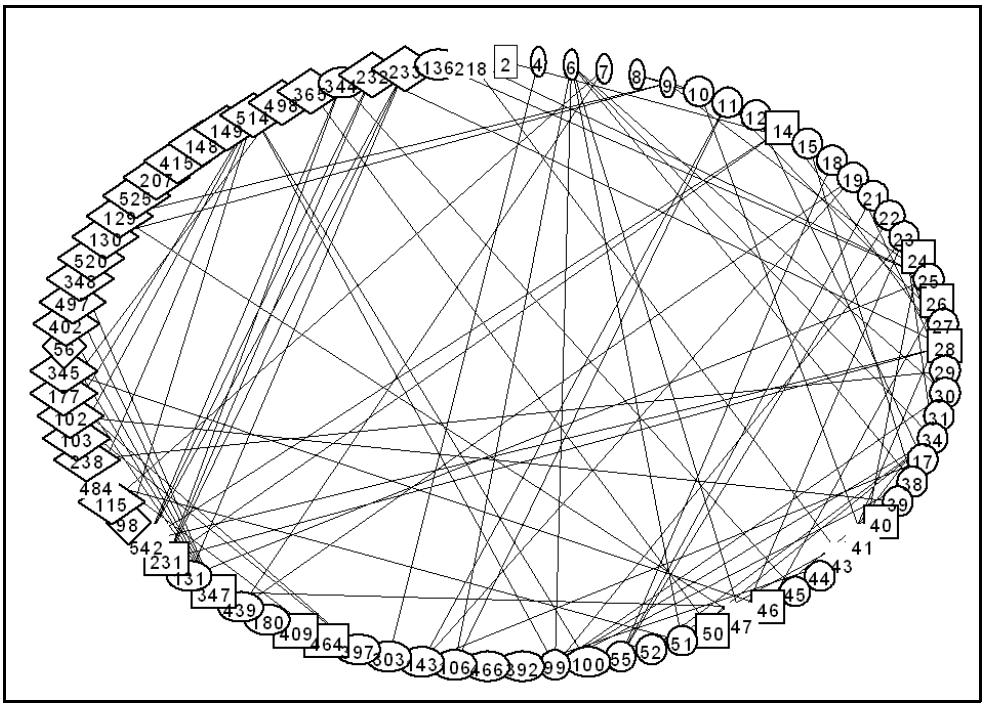

Figure 1. Friendship Network Circle Layout

Visualize a subset

In some cases, the user might find it helpful to break down the large graph into subsets. For instance, in the case of the investment banking data, the user might display the network for one group only. Here, we have extracted the European staff and Figure 2 shows that three groups of three or more people, two pairs of people, and seven isolates emerge when only European staff and their relations are considered. This approach limits the information that is displayed about the network (for instance, the actors who are displayed as isolates here might in fact be at the center of a group of non-European actors within the network). In some cases, it might be useful to compare images of the network even when they do not on their own tell the "whole story." The European network was displayed in KrackPlot by choosing the Hide option (Modify_ Hide_ Hide Type) to eliminate all other ethnic groups. Working interactively within KrackPlot, the user can hide and reinstate subgroups to explore the effect of their absence or presence on the overall structure of the graph. We could generate the same display for any subgroup or set of subgroups that have been identified as attributes in KrackPlot. A user might choose to represent a series of subsets of the graph to communication information about the graph.

Partition, group, or block and display relationships between partitions

The user may employ one of several techniques to identify roles or positions within a network. These relational approaches allow the user to translate complex networks into more simple forms.

Once nodes have been assigned to roles, the user can assign the same spatial positioning to all nodes in the same role by assigning the same Cartesian coordinates within KrackPlot. Figure 3 shows an

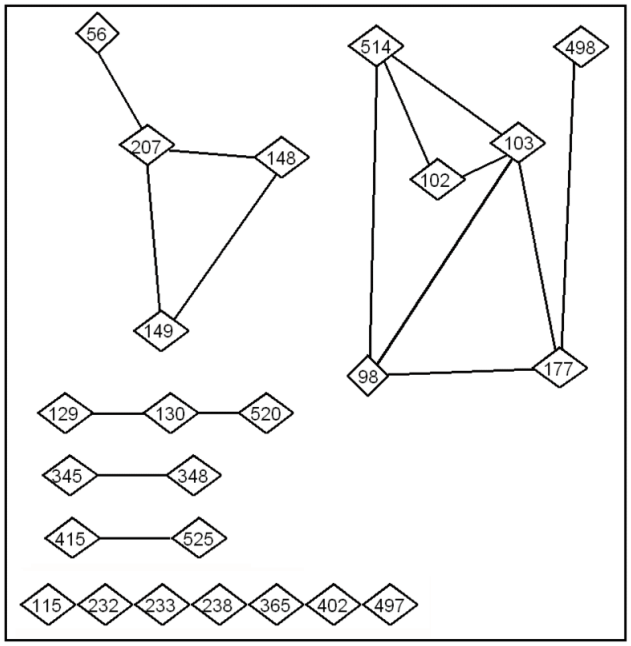

Figure 2. Friendship network for European

example of this using the same Wall Street investment bank data. We used UCINET V to identify roles using structural equivalence. Next we edited the KrackPlot file to assign the same coordinates to all nodes in the same role. We imported the edited KrackPlot file into KrackPlot. When the file is opened in KrackPlot, it appears as a reduced graph. In fact, all of the nodes are stacked up on each other. If the user holds the mouse over the stack and clicks, nodes will cycle through to the top of the stack. Any connections that exist among the structurally equivalent roles are portrayed as edges between the roles. Similarly, connections that exist within the structurally equivalent nodes in the same role are portrayed as self-reflected arrows back to the same position. To move a structurally equivalent group, the user must be careful to draw out a rectangle around the group. If the user just uses the mouse to drag the group, only the first node in the stack. We also added four nodes labeled "One" through "Four" to the representation to label the structurally equivalent roles. This approach pre-serves all of the information about the network while displaying only the reduced graph.

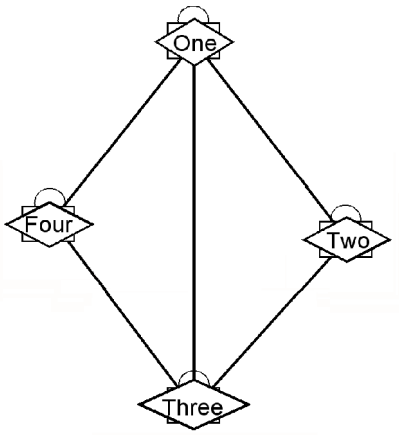

Figure 3. Reduced graph

Use automatic layout to focus in on an overall structure and then substructures

Users can explore large structures interactively within KrackPlot by using the available layout functions. Figure 4 shows network displayed using multi-dimensional scaling. While it is interest-

ing that the network looks like a velociraptor when displayed this way, it still conveys little information about the sttructure of the network. Figure 5 shows the network displayed using simulated annealing (and the default settings), an optimization routine that maximizes certain positive features of graph layout.

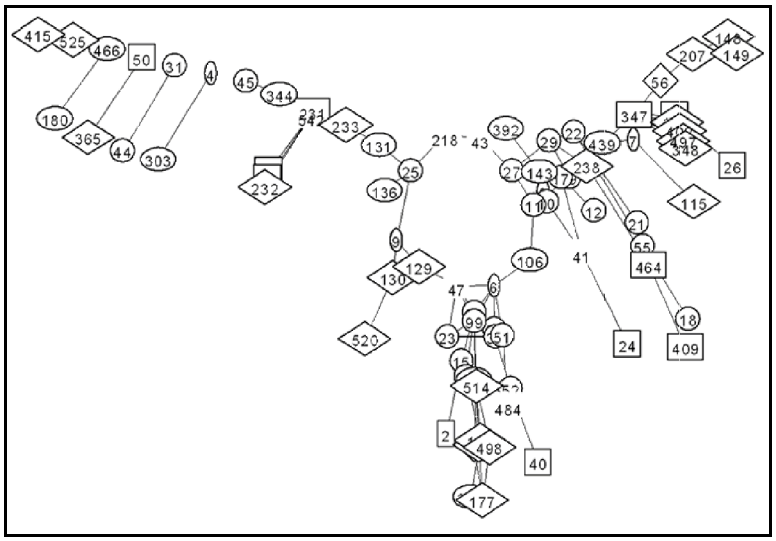

Figure 4. Multidimensional Scaling

Simulated annealing starts with the graph positions that are given. It then randomly moves an individual node to a point on the circumference of a circle defined around the node's current location, with a steadily decreasing radius. Once the node is moved, the routine reevaluates the new graph layout to determine if it is better or worse according to predefined graph layout features. The features are: nodes that are not too close to each other, edges that are not too long, edges that do not cross each other and nodes that do not go through edges. The "energy function", describing the attributes of the graph that will be optimized, is based on one suggested by Davidson and Harel

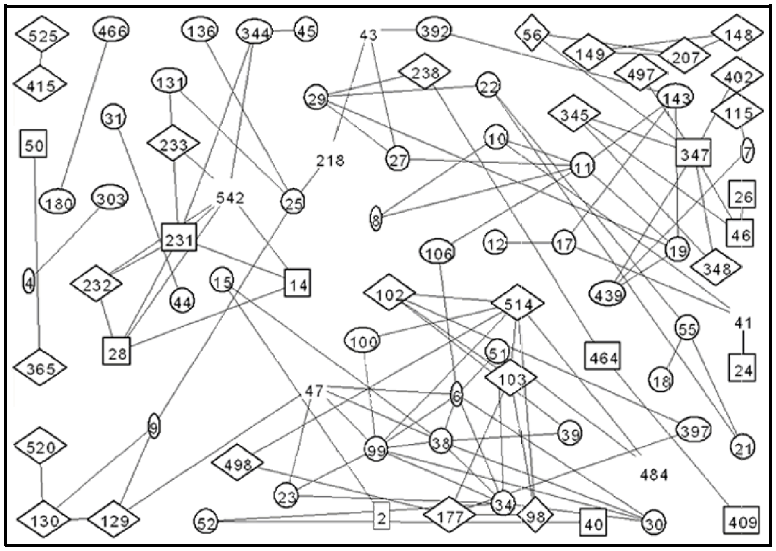

Figure 5. Anneal with default setting

(1989). If it is better, the new node position will be accepted. If it is worse, the new layout will be accepted with a small probability that depends on the "temperature" of the system and the amount worse that the new layout is. Simulated annealing will accept worse layouts with some probability to avoid local optima. Since simulated annealing begins the optimization routine from the initial graph layout, we have found it to be useful to start with a graph layout created using multidimensional scaling.

The default settings for annealing in KrackPlot were chosen for less complex graph. However, KrackPlot allows users to change the settings within anneal to attach different weights to each of the characteristics. The user can modify settings to accommodate more complex network information. In each annealing pass, the graph will be evaluated on these features using the default weights or the weights you provide in the "Settings" function. We will show how attaching different weights to the different graph features defined in the energy function can help the user uncover structure in a large graph. First, Figure 5 shows the bank staff friendship network layout using the default anneal settings. (Which are node repulsion = 1; edge repulsion = 0; edge repulsion in jiggle step = 1; edge length weight = 1; edge length variance = 0; edge crossing weight = 0; and weight on node hitting edge = 0.) The default settings for node repulsion keeps nodes away from each other and the default setting for edge length keeps connected nodes close to each other by keeping the edges between them short. As seen in Figure 5, using the default settings for simulated annealing does not uncover much structure in an 83-person network. When there are many nodes, the default setting for node repulsion tends to force the nodes to spread out too evenly on the page. The energy function pushes against the outside boundary of the picture.

Users can uncover more information about the structure of large graphs by working interactively with the annealing layout function and changing the weight attached to the annealing energy function. Also, using the “jiggle” function allows users to make refinement to the previously annealed layout.

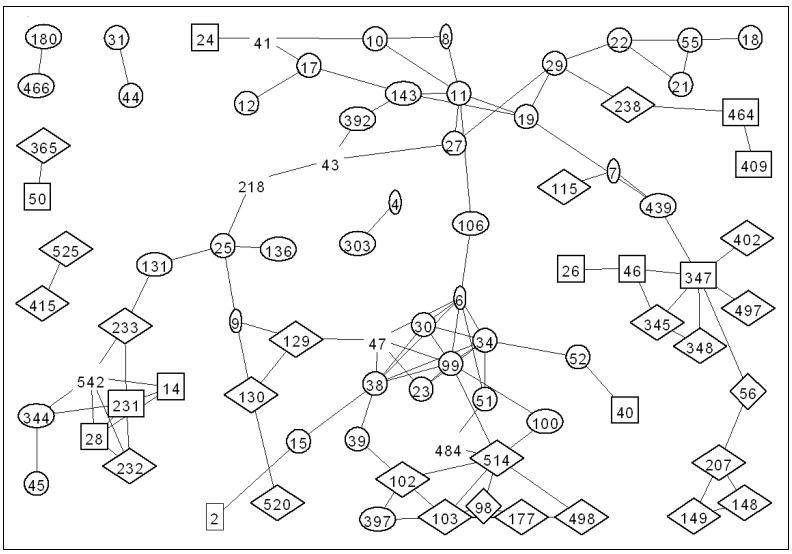

Figure 6. Anneal with Edge crossings=0 and Node repulsion=.1

The first change that we employ is to the weight assigned for node repulsion. Since there are 83 nodes in the network, we lower the node repulsion weight so that the nodes do not simply push against each other and against the boundary of the picture. We hold the edge length weight

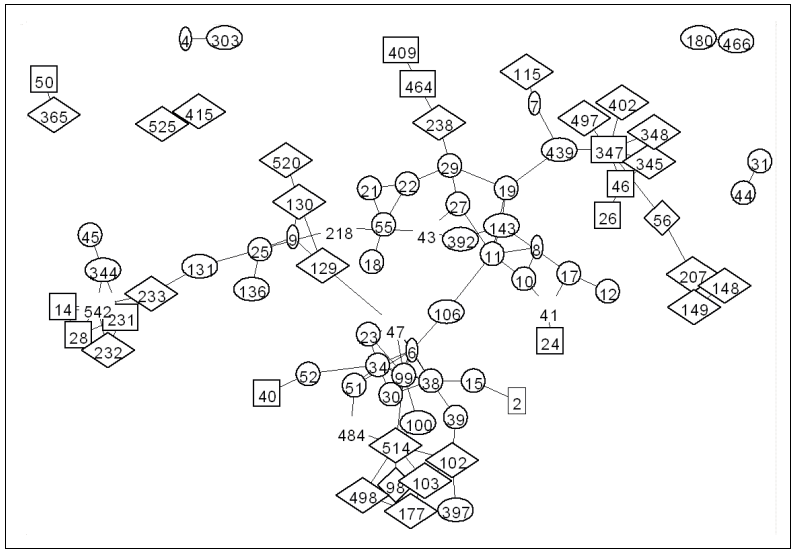

Figure 7. Anneal with Edge crossings=0, Node Repulsion=.01

constant at 1 so that in all versions of the layout, connected nodes stay close to each other. Figure 6 shows the result of lowering the node repulsion weight from 1 to .1; now the structure of the network begins to be more visible.

As we lower the node repulsion to .01 in Figure 7, we see that some groups and cluster emerge from the network. Figure 8 shows how the layout can be refined using the "jiggle" function in KrackPlot.

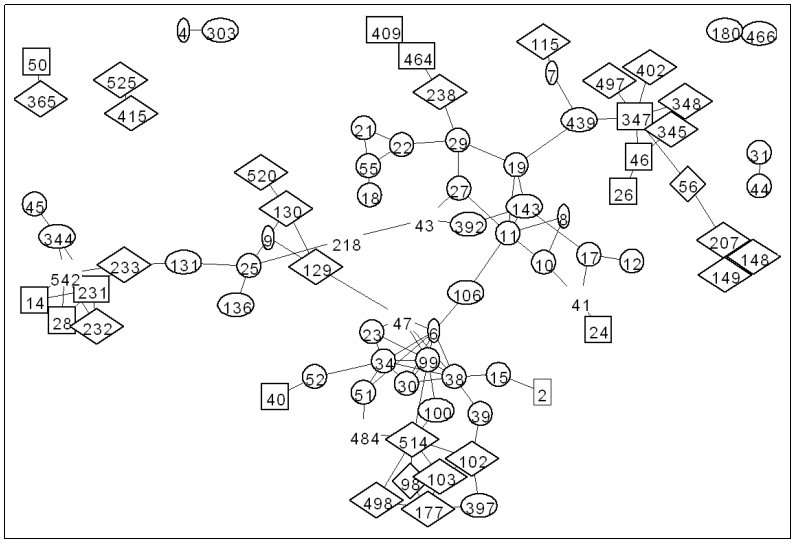

Figure 8. Jiggle prior picture with Edge Crossing for jiggle=.01

At this point, we introduce attention to limiting edge crossing by raising the weight on edge crossings from 0 to .01. Figure 8 shows little change from Figure 7, but the jiggle function does attempt to refine the display by reducing edge crossings. Figure 9 shows the result of using simulated annealing with the node repulsion set even lower, to .001. Here the connected nodes form into tight

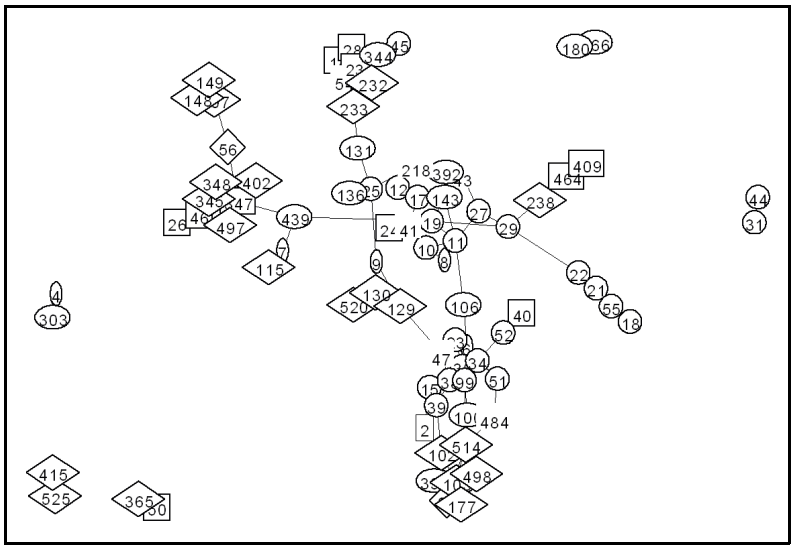

Figure 9. Anneal with edge crossings=0 and node repulsion=.001

clusters of overlapping nodes. While on its own, this display makes it rather difficult for viewers to extract information, it provides a good starting point for the jiggle refinement that is shown in Figure 10. For the layout displayed in Figure 10, we have taken the prior layout and refined it by including an edge crossing weight of .01 and increasing the node repulsion weight to .01. This

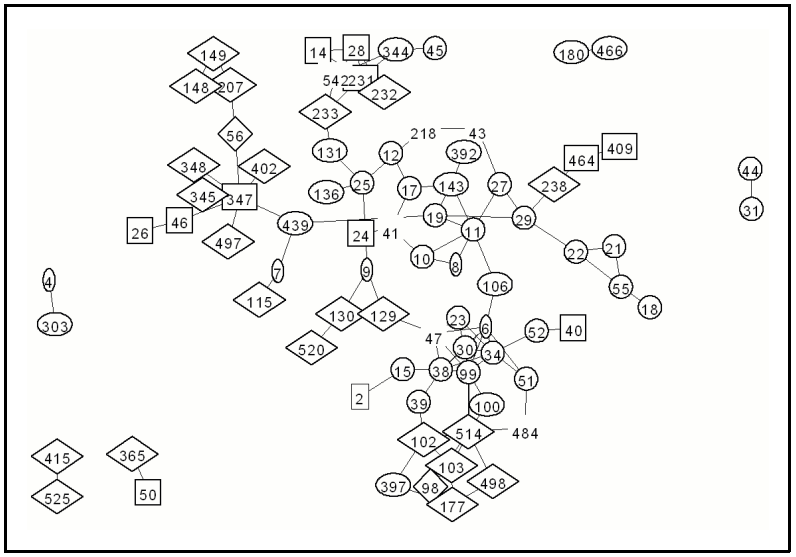

Figure 10. Jiggle prior picture with edge crossings=.01 and node repulsion=.01

process leads to a readable graph in which the structure of the network of 83 people emerges from the representation.

CONCLUSION

In this paper, we demonstrated several techniques for displaying complex network data using current software. We recognize that no one technique is best for displaying structural data under all circumstances. The amount of information, its complexity, and the salient features that are to be discerned in the picture all affect the choice of methods for display of such data. For example, in some cases, motion will be helpful; in other cases motion will obfuscate. Often times, as in the last investment banking example, there is a tradeoff between seeing the overall forest – the clusters of overall groups and their relative social proximity or ordering in relation to each other – and seeing the finer detail of the trees – identifying key players and roles within these groups. Interacting back and forth, changing the parameters to identify macro groups and then relaxing these parameters to reveal finer detail, provides a model for future work in automated and interactive display of complex network data of this kind.

But all of this progress leads us to ask another question. While we can produce faster and fancier network display programs, it is important to keep in mind that the purpose of all of this is to communicate important features of the structure to the viewer. To fully answer the question "What display technique is best" or even "What display technique is best in this circumstance", we need to better understand what the perceiver is learning or seeing in the display. To be sure, we can make more programs that seem to us as researchers/ programmers to make "better" pictures; but we are relatively ignorant of how general human perception interacts with these new fancy features. We believe that both kinds of research should go on in parallel. That is, new techniques of display should be evaluated for their ability to communicate structure to the user, and in turn new techniques can be developed to take advantage of what we find people "see" in particular display formats. Currently, it is our impression that there is a severe imbalance in this parallel research: Much more emphasis has been placed on methods of network data display and little on what people infer from structural displays. We certainly applaud the rapid progress in technology and would not want to diminish the enthusiasm of those who are diligently working to make finer and finer programs. We simply suggest that the other side of this progress also deserves equally enthusiastic efforts to reveal the human gain in understanding of social structures.

REFERENCES

Chen, C. 1999. *Information Visualisation and Virtual Environments*. London: Springer-Verlag.

Batagelj, V. and A. Mrvar. 1998. Pajek - Program for large network analysis. *Connections* 21: 47-57.

Friedman, R. and D. Krackhardt. 1997. Social Capital and Career Mobility. *Journal of Applied Behavioral Science*. 33: 316-334.

Krackhardt, D., J. Blythe, and C. McGrath. 1994. KrackPlot 3.0 An Improved Network Drawing Program." *Connections* 17: 53-55.

Freeman, LC. 2000. Visualizing Social Networks. *Journal of Social Structure*. 1(1).

McGrath, C. and J. Blythe. 2000. Influence of motion on human perception of dynamic networks. Presented to the XX International Social Network Conference. Vancouver, British Columbia. 2000.

McGrath, C., J. Blythe, and D. Krackhardt. 2001. Understanding human perception of dynamic representations of social networks. Presented to Schloss Dagstuhl Seminar No. 01271 on Link Analysis and Visualization. Saarbrucken, Germany.

Qin, Y., and H.A. Simon. 1992a. Imagery and mental models in problem solving. *American Association for Artificial Intelligence Spring Symposium Series: Working Notes*, 18-23.

Qin, Y., and H.A. Simon. 1992b. Imagery as process representation in problem solving. In *Proceedings of the 14th Annual Conference of the Cognitive Science Society*, 1050-1055.

Qin, Y., and H.A. Simon. 1995. Imagery and mental models in problem solving. In *Diagrammatic reasoning: computational and cognitive perspectives*, J. Glasgow, N.H. Narayanan, and B. Chandrasekaran, Eds.,403-434. Menlo Park, CA: AAAI/The MIT Press.

Richards, W. and A. Seary. 1999. MultiNet. Software tool.

Ware, C. 2000. *Information visualization: Perception for Design*. Morgan Kaufmann Publishers.

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Hyperlink Network Analysis: A New Method for the Study of Social Structure on the Web[1]

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This paper identifies hyperlink network analysis (HNA) as a newly emerging methodology. It suggests that social (or communication) structures on the web may be analyzed based on the hyperlinks among websites. Hyperlink network analysis has advantages in describing emerging structures among social actors on the web. In order to examine what constitutes hyperlink network analysis, this paper reviews prior research on the topic. Further, it describes the data-gathering techniques for those interested in hyperlink network analysis.

INTRODUCTION

The Internet represents a new channel for communication. As a result, we recently have witnessed a surprising growth of Internet studies across many disciplines.[3] Although researchers have conceptualized the Internet differently, it was originally characterized as the network of networks (Berners-Lee, 1999). The basic structural element of the Internet is the hyperlink. A hyperlink may be defined as a technological capability that enables one specific website (or webpage) to link with another.

[1] The author is grateful to George Barnett and Alexander Halavais for their insightful suggestions while writing the article.

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[3] The Association of Internet Researchers may be a good example. It was established with the advancement of the cross-disciplinary field of Internet studies. For more information, see the AoIR web site at: http://aoir.org

Hyperlinks let individuals or organizations running websites on the Internet expand their social or communication relations by making possible easy and direct contact among people or groups anywhere in the world. Using hyperlinks, people are able to have bilateral communication and coordination that crosses and/or strengthens off-line boundaries within and between organizations. In a hyperlink system, they can be linked together, exchange information, and maintain cooperative relationships by means of hyperlinks around a common background, interest, or project. This new form of communication structure can be seen on the world wide web.

As a methodology to study hyperlinks among websites, Jackson (1997) suggested that the methods of social network analysis (SNA) are applicable.[4] A social network is a set of nodes (people, organizations or other social entities) connected by a set of relationships, such as friendship, affiliation or information exchange (Wasserman & Faust, 1994). SNA is a set of research procedures for identifying structures in social systems based on the relations among the system components (also referred to as nodes) rather than the attributes of individual cases (Rogers & Kincaid, 1981; Richards & Barnett, 1993). SNA may be useful for understanding the interplay between computer-mediated social processes (Garton, Haythornthwaite, & Wellman, 1997). In particular, Jackson argued that hyperlink-based network analysis is a strong approach for studying the representation and interpretation of the web communication structure. Recently, several researchers have taken a hyperlink-based approach to investigate the Internet. To these researchers, hyperlinks on the web are considered not simply as a technological tool but as a newly emerging social (or communicational) channel. The website is regarded as an actor and the hyperlink among sites represents a relational connection or link.

The purpose of this paper is to identify a new and growing area of interest: hyperlink network analysis (HNA). This paper reviews the past research that used HNA, examines the implications for the study of the social structure on the web, and describes data-collecting techniques for HNA.

DEVELOPMENT OF SOCIAL NETWORKS

From Social Network to CMC Network. SNA focuses on patterns of relations among people, organizations, or nation states (Wasserman & Faust, 1994). This research approach has rapidly developed in the past twenty years, principally in sociology (Galaskiewicz & Wasserman, 1993; Wellman & Berkowitz, 1989), science studies (Ben-David & Collins, 1966; De Solla Price, 1986; Mullins, 1972), and communication science (Richards & Barnett, 1993; Rogers & Kincaid, 1981; Monge & Contractor, 2000). As presented in Table 1 and in Figure 1, a social network is composed of nodes (people, groups, organizations or other social entities such as nation-state) connected by a set of relationships (Wellman & Berkowitz, 1994). Compared to this, a communication network

[4] Before moving onto further discussion, we should make a few things clear. Jackson (1997) argued that the methods of SNA are useful in studying the hyperlink-mediated web communication. A distinction must be made between those hyperlink researchers who adopted SNA as their methods and others who didn't (e.g., Henzinger, 2001; Kleinberg, 1999; Thelwall, 2001). The two groups of research appear similar but they differ in that some do or do not use the methods of SNA. We call the research which employed SNA hyperlink network analysis (HNA) research. Because both groups have contributed to shaping the new method, this paper artificially conflates the two somewhat in order to elicit the nature of HNA (Brunn and Dodge, 2001; Halavais, 2000; Palmer, Bailey, and Faraj, 2000).

Table 1. Comparison between Hyperlink Network and Other Networks

Type of Network	Conceptual Definition	Operational Measure	Content of Relation/Link
Social Network	A set of people (or organizations or other social entities) connected by a set of relationships	Individual, Group, Organization, Nation-State	Any Kind of Social Relation
Communication Network	A network composed of interconnected individuals linked by patterned flows of information	Same as above, but generally focuses on individual people	Communication and Information
Computer-mediated Network	A specific type of communication network in which individuals are interconnected by computer systems	Same as above, but also includes computer systems	Same as above, but restricted to computer as channel of information flow
Internet Network	A communication network connected by the Internet among computer systems	Same as above, but focuses on Internet users	Same as above, but restricted to Internet as channel of information flow
Hyperlink Network	An extension of traditional communication networks in that it focuses on the structure of a social system based on the shared hyperlinks among websites	Same as above, but focuses on websites which represent Individuals, Groups, Organizations, Nation-States	Same as above, but restricted to hyperlink as channel of information flow

* Examples of each network can be readily found from the following references: Garton, Haythornthwaite, & Wellman (1997), Monge & Contractor (2000), Rice (1994), Richards & Barnett (1993), Rogers & Kincaid (1981), Wasserman & Faust (1994), and Wellman & Berkowitz (1989).

is a network composed of "interconnected individuals who are linked by patterned flows of information" (Rogers & Kincaid, 1981, p.346). The nodes in a communication network are the same as those in a traditional social network (generally individual people); the contents of the social relation (or link) are communication exchanges or information transfers. With the development of communication/information technologies, the approaches scholars have developed to analyse communication networks have becoming increasingly diverse: computer-mediated communication (CMC) networks, Internet networks, and hyperlink networks.

CMC network analysis places its focuses on a specific type of communication network in which individuals are interconnected by computer systems including computer conferencing, computer bulletin boards, facsimile, and group decision support systems (Rice, 1994). Scholars studying CMC networks (or networking) emphasize computer systems as the channels of information flow. With the emergence of the Internet, a communication network among computer systems connected by the Internet forms an important CMC network. The following section reviews recent studies that use SNA in the CMC environment.

In the past, several researchers have examined communication networks among computer conference users (Danowski & Edison-Swift, 1985; Rice, 1982; Rice & Barnett, 1986). Following this approach, Paccagnella (1998) used SNA to examine the structural communication pattern of Italian

cyber_punk computer conferences. In addition to network analysis, he has applied content analysis to find how different types of language are used according to a participant's position in the network. He found that an actor's centrality is positively correlated with the use of computer network slang and terms which show a collective identity.

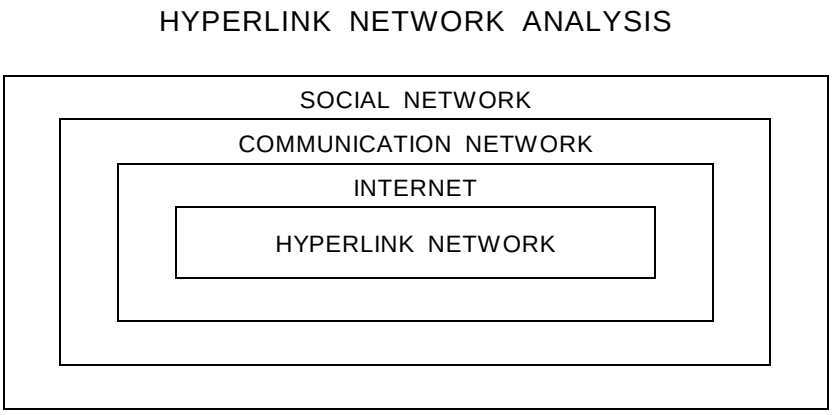

Figure 1. Relation between Hyprlink networks and other Social or Communication networks

Haythornwaite and Wellman (1998) used network analysis to examine the pattern of relations and media use among 25 computer scientists in a university research group based upon their working and friendship relations, the frequency of communication, the information exchange relationship, and the types of media used. They found that those who communicated more frequently were involved in more types of information exchange relationships and used different media. The amount of usage of each medium was also higher. The closeness of work ties and of friendship ties respectively had a positive impact on those relationships. The type of information being exchanged influenced the types of media used. For example, electronic mail was more often used in work-oriented relationships than in socializing and exchanging major emotional support.

Kang and Choi (1999) analyzed the network of message flows among usenet users. Looking at cross-posting patterns of international news on the Internet, they analyzed the news content posted by users according to destination (country, region, or international organization). The results were consistent with the past world-system research on international communication: dominance of traditional core countries like the United States, the United Kingdom, and Japan; and Chinese-dominated Asian countries' move toward the core (Barnett, 2001). Also, international organizations such as the United Nations and the World Bank were relatively central in the international news flow network.

Computer conference participants, coworkers, usenet users, and online networks of learners are at the centre of network-oriented CMC studies. Haythornthwaite (2000), using survey and interview data from four computer-supported distance learning classes, investigated the communication networks among the students. She analyzed the individuals' ego networks in an online learning environment in terms of size, type and pattern of relationship. She found that the characteristics of online networks were similar to those of offline social networks. The student's network sizes were in proportion to class size but the strength of this relationship decreased as class size increased. Compared to the least frequent communicators, more frequent communicators had more social and emotional interactions that were more supportive of current and future relationships. Also strongly connected students tended to use more Internet Relay Chat (IRC) and email to maintain the relations.

In contrast to these studies, Hampton and Wellman (2000) extended the role of CMC to offline life. In a study of a high-technology village in Canada, they used four methods (ethnographic observation, computer-assisted surveys, monitoring an online community forum, and focus groups) to examine the residents' community ties online and offline after the introduction of a high-speed network. They found that the wired village's residents had more social interactions including conversation and visiting in comparison to their non-wired counterparts. They argued that online network served to make social ties among residents stronger and denser, as the Internet was used more for local social contacts than for global communication.

In the context of CMC, social network researchers have concentrated on how specific social or technical attributes of computer-based media influence how people communicate with others (Rice, 1994; Garton *et al*., 1997). These scholars have focussed on how people use CMC to maintain relations or on what communication network structures online look like. This tendency still prevails. However, one body of research examines actors linked by the hyperlinks on their websites rather than the individuals themselves.

NEW CMC NETWORK: HYPERLINK NETWORK

Recent studies of CMC networks have tended to examine the structural relationship between people and how their positions in the network affect their behavior and attitudes. They have been interested in how individuals' lives, embedded in a CMC environment, affect their interpersonal relations with coworkers, friends, classmates, residents, computer conference users, and online group members. In this research, the nodes in the networks have been individual people.

Recently, a group of scholars have begun to describe websites as actors. From this perspective, an actor is a website belonging to a person, private company, public organization, city, or nation-state. These nodes are linked by their hyperlinks. Hyperlink network analysts argue that despite the Internet's brief existence, its increasing role in communication has been made possible by the continual change in the structure of the network of hyperlinks. Patterns of hyperlinks designed or modified by individuals or organizations who own websites reflect the communicative choices, agendas, or ends (Jackson, 1997) of the owners. Thus, the structural pattern of hyperlinks in their websites serves a particular social or communicative function.

The Internet is a communication network made up of intertwined connections through which a number of messages travel. In this process, a website functions as a node that passes messages and determines their paths according to a selection of hyperlinks.[5] In particular, through a hyperlink, an individual website plays the role of an actor who could influence other website's trust, prestige, authority, or credibility (Kleinberg, 1999; Palmer, Bailey, & Faraj, 2000; Park, Barnett, & Nam, 2001). Hyperlinks as connections represent networks among people, organizations, or nation-states. Thus, we can interpret the social or communication structure among those social actors based on the hyperlink structure.

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[5] While any individual or institution has complete freedom in choosing the direction of hyperlinks on their websites (or webpages), research by Albert, Jeong and Barabasi (1999) shows that the web has "the flocking nature." According to them, if you select two webpages at random, you can get from one page to the other by clicking on an average of 19 hyperlinks. This is not a geometric distance but one due to the pattern of connections, e.g., a topological distance (see Hayes, 2000). In fact, the probability that there is a hyperlink between two randomly chosen websites is nearly 0 (Terveen & Hill, 1998). The web as a whole is a very spare network.

A HYPERLINK NETWORK ANALYSIS: A REVIEW OF RESEARCH

This section reviews the prior research that conducted a HNA within the topics of international communication, e-commerce, interpersonal communication, and interorganizational communication. Also, it briefly describes how to collect hyperlink data for HNA.

International Communication. International information flow has been perceived as a primary topic in the study of international communication (Barnett & Salisbury, 1996; Barnett, 1999; Barnett *et al.*, 2001). In the "information society," drawing the information flows among nation-states based upon their hyperlinks may be a necessary first step in mapping the new structure of international communication (Brunn & Dodge, 2001; Halavais, 2000, Hargittai, 1999).

Halavais (2000) examined the role of geographic borders in cyberspace using the hyperlink pattern of websites. Specifically, he took a sample of 4,000 websites and analyzed their external hyperlinks and determined the total percentage of hyperlinks from the sites to various countries. Domains, which did not contain their geographic locations (for example, .com or .edu), were checked against the WhoIs registry to determine the country of origin.

In a study on the structure of global commerce on the web, Brunn and Dodge (2001) used a similar method to analyze the inter-domain hyperlinks among 174 geographic TLDs (top-level domains, such as .ca for Canada). They treated website's incoming and outgoing links separately, even though they did not perform a SNA. They developed a domains-by-domains matrix of inter-hyperlinks upon which they conducted descriptive statistics and cross-tabulation analysis by country and region (North America, Europe, Australia, South America, Central American & Caribbean, South America, North Africa, Sub-Saharan Africa, South Asia, Southeast Asia, and East Asia).

Barnett, Chon, Park, and Rosen's (2001) study differed from the above research in that it used network analysis. They used secondary data published by the Organization for Economic Co-operation and Development (OECD, 1998). The data included the number of hyperlinks embedded in websites between all TLDs among OECD member countries. Network analysis enabled them to determine how central (or peripheral) each country is and to identify groups of countries, and underlying dimensions in the hyperlink network. Further, they employed quadratic assignment procedure (QAP) to evaluate the strength of the relationship between the hyperlink network and other social and communication networks (international telecommunications, trade, air traffic, telephone rates, language, physical location, science citations, student, immigrant flows and structural asynchrony). The authors argued that the hyperlink network analysis addressed two aspects of global communication. First, it reveals the influence of national borders on the Internet and second, it indirectly reveals the structural pattern of international information flow among nation-states.

E-commerce. Palmer *et al.* (2000) used the hyperlink method to examine e-commerce. When purchasing a commodity online, a consumer's trust (or perceived credibility) of a website has been regarded as one of the most influential factors in transaction process (Gefen, 2000; Tseng & Fogg, 1999).[6] Based upon this theory, they used the number of inward hyperlinks to a website as an

[6] One might ask whether trust and credibility are synonymous concepts. In other words, how different (or similar) are the two? According to Tseng and Fogg (1999), trust generally indicates a positive belief about the perceived dependability of a person, object, or process. It is different from credibility when involving the

indicator of the trust of Internet firms. They obtained the data from Alexa.com. The results revealed that the number of incoming links was strongly related with the use and prominence of TTPs (Trusted Third Parties) and privacy statements which are regarded as another trust indicator. Their research method was similar to a traditional network analysis that measures individual's prestige in terms of the number of friends who choose the person as their representative.

Krebs' (2000) study of Amazon.com indirectly revealed the role of hyperlinks in relation to homophilous attribute among online consumers. Amazon.com provides customers with information about *who bought this book also bought these books*. It has a hyperlink so that prospective customers can take a look at the hyperlinked books directly. Krebs argued that the fact that people with similar interest bought those books contributes to persuading prospective consumers to buy them. Choosing a specific book as a focal node, he built an "ego" and "alter" network among books. This enabled him to see how the hyperlinked books are inter-connected and what position they occupy in the networks. Also, the books were clustered according to a topic and he analysed the role of individual book within cluster and among clusters.

While analysing the affiliation network among Korea's 152 most frequently visited commercial websites, Park *et al.* (2001) regarded the number of hyperlinks incoming to a website (and the outgoing links originating from the site) as an indicator of the credibility of the site. They created a websites-by-websites relations matrix based on the existence of hyperlinks in a webpage titled "affiliation program." Websites that did not play a significant role in the network (e.g., isolates) were excluded. Finally, the 44 group websites identified by NEGOPY were used in the research. They measured centralities and found that the structure of the affiliation network was influenced by the financial websites with which others are affiliated.

Park *et al.* (2001) explained websites' hyperlink affiliation networks as a function of the credibility among websites and the desire to strengthen certain dimensions of credibility. A website perceived highly credible gets more links from others. The strength of links, in this case, the number of incoming hyperlinks, is an indicator of the website's credibility. Thus, website position relative to other commercial websites could be examined as a hyperlink network.[7] They argued that hyperlink network analysis has an advantage to answer important questions: What does the associational structure among websites look like? What element makes websites form networks with others on the Internet? Their research provided a useful theoretical basis for applying HNA to a web-based system. Their perspective recognized individual websites as independent actors, which together comprise a system.

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effectiveness of technological capability, like, for example, a trust system frequently used in computer technology (Stefik, 1999). But it can be used synonymously with credibility when referring to the psychological attribute such as people's beliefs or expectations.

[7] Past studies support this hypothesis. Terveen and Hill (1998) studied the use of the number of hyperlinks between websites as an indicator of the quality of sites and found that hyperlink connectivity had a significant relationship to the expert quality judgments of sites. Also, the indegree connectivity of a site (the number of sites that are linked to a given site) was positively correlated with judgments. Further evidence can be found in more recent studies. A series of studies conducted by Persuasive Technology Laboratory at Stanford University have found that having a partner website hyperlinked may influence people perceived credibility of certain sites (Fogg *et al*., 2001). Thus, a website that intends to increase its credibility adds hyperlinks to credible websites. A website perceived as highly credible receives many links from others.

Vedres and Stark's (2001) approach is similar to that of Park *et al.* (2001). In order to find the most prestigious Hungarian websites, they traced out the hyperlinks originating from 170 sites selected in terms of their presence in the most popular web directories. Measuring the most authoritative site based on the number of links on other sites may be more reliable (or valid or reasonable) than using the number of hits or visitors (Henzinger, 2001; Kleinberg, 1999; Terveen & Hill, 1998).

Interpersonal and Interorganizational Communication. The research described above shows that the structure of hyperlinks among websites may be used to measure the international communication flow and individual website's credibility. The following studies use a HNA to examine interpersonal and interorganizational communication.

Park, Barnett, and Kim (2000) analyzed a hyperlink network among Korea's political parties and assemblymen in which the nodes were their websites. They developed a sites-by-sites matrix of hyperlink existence upon which they conducted hierarchical cluster analysis. In addition to describing the hyperlink network of politicians, they examined the relationship between the structure of the hyperlink network and shared party membership. They found that the structure of their hyperlink network is significantly related to party membership.

Adamic and Adar (2001) focused on university students' (Stanford University and the Massachusetts Institute of Technology) homepages and described hyperlink connections between them. They found that some students had more than 30 incoming and/or outgoing hyperlinks while some of their schoolmates did not have any links. In order to find a connector who plays a key role in linking other homepages in the university, they measured the average shortest path between any two homepages (9.2 for the Stanford network and 6.4 for the MIT). They concluded that these results may reflect the existence of a small world network online as well as in the offline world (Milgram, 1967; Watts & Strogatz, 1998). Besides, they examined what two students hyperlinked have in common using the content analysis of homepages. At the interorganizational level, Bae and Choi (2000) employed bilateral hyperlink networks among websites, to capture the structure of hyperlink communication between 402 human rights non-governmental organizations (NGOs). They found that many NGOs form a hyperlink network with others according to the similar aim or activities rather than geographic location. This certainly warrants further research: How similar is the clustering of organizations based upon the content analysis of mission statements to that of HNA?

In order to describe the coordinational forms of the Hungarian Internet market, Vedres and Stark (2001) conducted a multiple network approach comparing hyperlink network with other networks such as the backbone and webhosting networks. They were able to estimate the overall structural similarity among major organizations supporting the Internet economy.

In the context of interpersonal and interorganizational communication, HNA is certainly a worthwhile method. Thanks to HNA, a researcher is able to identify an invisible network in the field of human and/or organization communication. HNA rendered visible a latent network among people or organizations that did not appear when only focusing on the organizations and their members' relationships. Also, hyperlink analysis has the advantage of being unobtrusive (Garton, *et al.*, 1997; Webb, 1966). Hyperlink data can be gathered naturally without intruding in the research context. This can avoid sensitive issues that result from obtrusive observation in the Internet: monitoring, physical fatigue, and privacy.

DATA GATHERING METHODS

Data on hyperlink networks between websites can be obtained in two ways: 1) observation and 2) computer-assisted measurement.

First, a researcher is able to gather hyperlink data through direct observation. Park *et al.* navigated 152 websites which are the most frequently visited sites among Korean web users (Park *et al.*, 2001) and 273 assemblymen websites and 5 political party's sites in Korea (Park *et al.*, 2000). Based on the result of these observations, they measured who was linked to whom, in this case, which website linked to which other site.

There is no doubt that direct observation has been a central measurement tool for gathering network data. Nevertheless, the use of human coders has limitations. It requires a researcher to surf websites and many webpages within each site carefully. When it is used for large number of sites, there is a high labor cost and the possibility of coding errors.

For these reasons, computer-assisted measurement is recommended. Past research in the field of CMC has used computer-assisted tools to gather social network data (Hampton, 1999). The ideal method is to use a computer program that has been developed for HNA. However, to our knowledge, no program provides exactly what a social network analyst is looking for. In response to this situation, some researchers have written programs (Bae & Choi, 2000; Halavais, 2000; Terveen & Hill, 1998). Although this process seems to be more effective than traditional observation methods, it is also problematic. The program used varies according to a researcher. In other words, measurement tool may be idiosyncratic answering only the research question being investigated. Also, access to these programs is limited, preventing other researchers from replicating their results. Different ways of gathering data may cause different research results.

In fact, the difficulty in deciding on data-gathering tools is a common issue for the Internet research community (Jones, 1999; Mann & Stewart, 2000). In order to determine the validity and reliability of a research method, a data-collecting tool needs to be reliable and accessible at an affordable price. The measurement tool should be available to the researcher without any serious barriers. Alternatively, a search engine has been proposed as a proper tool to trace the hyperlinks among websites (Adamic & Adar, 2001; Brunn & Dodge, 2001).[8] The AltaVista may be good example; they are able to record in-going and outgoing link separately.[9] It should be noted that none of the search engines commonly used among web users produces outcomes tailored for a network analysis. The network researcher needs to transform the results generated by search engines into sociomatrices.

CONCLUSIONS

This paper has focused on HNA as new methodological tool and provided some techniques for collecting hyperlink data. HNA is an extension of traditional network analysis in that it focuses on the structure of a social system based on the shared links among communication partners. The

[8] However, there is a criticism about the academic use of search engine for hyperlink analysis. Snyder & Rosenbaum (1999) cast a question about the reliability of the results from search engine.

[9] For the detailed search command of AltaVista, refer to the advanced query of altavita.com.

difference between hyperlink and traditional network analysis is the use of hyperlink data which can be obtained only from websites. In other words, two nodes, in this case, two websites, are connected in a hyperlink network to the extent that there are hyperlinks between them. Thus, HNA requires a content analysis of HTML (Hyper Text Markup Language) data to determine if there is bilateral hyperlink between two websites or how many hyperlinks they share throughout webpages. Hyperlink network analysts based their theoretical framework on the assumption that the relations among a set of those actors on the web may be analyzed in terms of the connections on their websites. They argued that hyperlink analysis not only reveals the social structure of the Internet, but also can be used to examine the communication among actors.

But HNA research has not addressed the following questions fully: First, are meaningful communication relations being maintained or transmitted via hyperlinks? Is there structural information flow through hyperlinks, connecting individuals, organizations, or countries? How are hyperlinks, as the channel of information flow, related (or unrelated) to offline (or online) other channels? Secondly, as Barnett *et al.* (2001) put it, new communication networks are in the process of evolution incorporating other elements from within the existing social system. Hyperlink networks among websites and social networks in the physical world may be seen as co-constructing each other, such that offline relationships can influence how online relationships are developed and established. Similar questions arise: How do hyperlink relationships articulate wide-ranging offline (or other online) ties? Do they really reflect social networks in the physical world? Or do they contribute to building online relationships across offline boundaries? Thirdly, the wider the Internet's global reach, the greater the number of regional and national preferences (or cultures). Do cultural differences influence the hyperlink network structure among websites? Fourthly, what does the location of websites in the hyperlink networks mean? In other words, what do centrality measures (such as in/out degree, betweenness, and closeness) tell us? Are they reliable indicators of credibility, reputation, or quality contents? Lastly, researchers have argued why a website chooses to hyperlink with a certain site. What leads to an increase (or decrease) in a website's current and future links? When deciding to hyperlink with other websites, what elements are involved? Several important questions seem unanswered from the prior research. Future research needs to elaborate the questions unanswered in relation to the nature of hyperlinks. In addition, in order to overcome certain limitations of HNA, several methods need to be employed to examine the reasons developers of websites form a network with other sites via hyperlinks: survey, in-depth interviews, observation, comparative analysis of website contents and other network data would contribute to an understanding of the social relationships among the network's components, in this case, the websites (Lievrouw, *et al.*, 1987). In other words, this methodological strategy has strength in identifying hyperlink networks among websites, examining why and how websites are interconnected.

REFERENCES

Adamic, L.A. and E. Adar. 2001. You are what you link. Presented to the 10th annual International World Wide Web Conference, Hong Kong. Retrieved June 19, 2001 from: http://www10.org /program/society/yawyl/YouAreWhatYouLink.htm.

Albert, R., H. Jeong, and A.L. Barabasi. 1999. Diameter of the world wide web. *Nature, 401*(9): 130-131.

Bae, S. and J.H. Choi. 2000. Cyberlinks between human rights NGOs: A network analysis. Paper presented to the 58th annual national meeting of the Midwest Political Science Association, Chicago.

Barnett, G.A. 2001. A longitudinal analysis of the international telecommunication network, 1978-1996. *American Behavioral Scientist, 44*(10): 1638-1655.

Barnett, G.A. 1999. The social structure of international telecommunications. In Sawhney, H. and G.A. Barnett. (Eds.) *Progress in communication sciences, Volume XV: Advances in telecommunications* , 151-186. Stanford, CT: Ablex.

Barnett, G.A., and J.G.T. Salisbury. 1996. Communication and globalization: A longitudinal analysis of the international telecommunication network. *Journal of World System Research, 2*(16): 1-17.

Barnett, G.A., B.S. Chon, H.W Park, and D. Rosen. 2001. Network analysis of international Internet flows. Presented to the International Sunbelt Social Network Conference, Budapest, Hungary.

Ben-David, J. and R. Collins. 1966. Social factors in the origins of a new science: The case of psychology. *American Sociological Review, 31*: 451-465.

Berners-Lee, T. 1999. *Weaving the web: The original design and ultimate destiny of the World Wide Web by its inventor.* New York: Harper Collins Publishers.

Brunn, S.D. and M. Dodge. 2001. Mapping the 'Worlds' of the world wide web: (Re)Structuring global commerce through hyperlinks. *American Behavioral Scientist, 44*(10): 1717-1739.

Danowski, J. and P. Edison-Swift. 1985. Crisis effects on intraorganizational, computer-based communication. *Communication Research, 12*(2): 251-270.

De Solla Price, D.J. 1986. *Little science, big science...and beyond.* New York: Columbia University Press.

Fogg, B.J., J. Marshall, O. Laraki, A. Osipovich, C. Varma, N. Fang, J. Paul, A. Rangnekar, J. Shon, P. Swani, and M. Treinen. 2001. What makes web sites credible? A report on a large quantitative study. Presented to the Computer-Human Interaction Conference, Seattle, Washington.

Galaskiewicz, J. and S. Wasserman. 1993. Social network analysis: Concepts, methodology, and directions for the 1990s. *Sociological Methods & Research, 22* (1): 3-22.

Garton, L., C. Haythornthwaite, and B. Wellman. 1997. Studying online social networks. *Journal of Computer-Mediated Communication, 3*(1). Retrieved September 19, 2000 from: http://www. ascusc.org/jcmc/vol3/issue1/garton.htm.

Gefen,D. 2000. E-commerce: The role of familiarity and trust. *OMEGA-International Journal of Management Science, 28*(6): 725-737.

Halavais, A. 2000. National borders on the world wide web. *New Media & Society, 2*(1): 7-28.

Hampton, K.N. 1999. Computer assisted interviewing: The design and application of survey software to the wired suburb project. *Bulletin de Methode Sociologique (BMS), 62*: 49-68.

Hampton, K.N. and B. Wellman. 2000. Examining community in the digital neighborhood: Early results from Canada wired suburb. In Ishida, T. & Isbister, K. (Eds.), *Digital cities: Technologies, experiences, and future perspectives*, 194-208. Heidelberg, Germany: Springer-Verlag.

Hargittai, E. 1999. Weaving the Western Web: Explaining differences in Internet connectivity among OECD countries. *Telecommunications Policy, 23*: 701-718.

Hayes, B. 2000. Computing science graph theory in practice: Part 1. *American Scientist, 88*(1): 9-13.

Haythornthwaite, C. 2000. Online personal networks: Size, composition and media use among distance learners. *New Media & Society, 2*(2): 195-226.

Haythornthwaite, C. and B. Wellman. 1998. Work, friendship and media use for information exchange in a networked organization. *Journal of the American Society for Information Science, 46*(12): 1101-1114.

Henzinger, M.R. 2001, Hyperlink analysis for the web. *IEEE Internet Computing 5*(1): 45-50.

Jackson, M.H. 1997. Assessing the structure of communication on the world wide web. *Journal of Computer-Mediated Communication, 3*(1). Retrieved September 19, 2000 from: http://www.ascusc. org/jcmc/vol3/issue1/jackson.htm

Jones, S. 1999. *Doing internet research: Critical issues and methods for examining the net.* Thousand Oaks, CA: Sage.

Kleinberg, J.M. 1999. Hubs, authorities, and communities. *ACM Computing Surveys, 31*(4). Retrieved March 2, 2001 from: http://www.cs.brown.edu/memex/ACM_HypertextTestbed/papers/10.html

Krebs, V. 2000. Working in the connected world book network. *IHRIM (International Association for Human Resource Information Management) Journal, 4*(1): 87-90.

Lievrouw, L.A., E.M. Rogers, C.U. Lowe, and E. Nadel. 1987. Triangulation as a research strategy for identifying invisible colleges among biomedical scientists. *Social Networks, 9*: 217-248.

Mann, C. and F. Stewart. 2000. *Internet communication and qualitative research: A handbook for researching online.* Thousand Oaks, CA: Sage.

Milgram, S. 1967. The small world problem. *Psychology Today, 1*(1): 60-67.

Monge, P. and N.S. Contractor. 2000. Emergence of communication networks. In Jablin, F.M., & Putnam, L.L. (Eds.), *The new handbook of organizational communication: advances in theory, research, and methods*, 440-502. Thousand Oaks, CA: Sage.

Mullins, N. 1972. The development of a scientific specialty: The phage group and the origins of molecular biology. *Minerva, 19*: 52-82.

OECD 1998. *Working paper on telecommunication and information service policies: Internet infrastructure indicators.* Paris: OECD.

Paccagnella, L. 1998. Language, network centrality, and response to crisis in on-line life: A case study on the Italian *cyber_punk* computer confernce. *The Information Society, 14*: 117-135.

Palmer J.W., J.P. Bailey, and S. Faraj. 2000. The role of intermediaries in the development of trust on the WWW: The use and prominence of trusted third parties and privacy statements. *Journal of Computer-Mediated Communication, 5*(3). Retrieved Jun 22, 2000 from: http://www .a sc us c. or g/ jcmc/vol5/issue3/palmer.htm

Park, H.W., G.A. Barnett, and I.Y. Nam. 2001. Affiliation network structure of top websites: Examining affiliates with hyperlink in Korea. Presented to the International Sunbelt Social Network Conference, Budapest, Hungary.

Park, H.W., G.A. Barnett, andC.S. Kim. 2000. Political communication structure in Internet networks: A Korean case. *Sungkok Journalism Review, 11*: 67-89.

Richards, W.D. and G.A. Barnett (Eds). 1993. *Progress in communication science, 12.* Norwood, NJ: Ablex.

Rice, R.E. 1994. Network analysis and computer-mediated communication systems. In Wasserman, S., & Galaskiewicz, J. (Eds.), *Advances in social network analysis*, 167-203. Thousand Oaks: Sage.

Rice, R.E. and G.A. Barnett. 1986. Group communication networking in an information environment: Applying metric multidimensional scaling. In McLaughlin, M. (Ed.) *Communication Yearbook, 9*: 315-338. Beverly Hills, CA: Sage.

Rice, R.E. 1982. Communication networking in computer-conferencing systems: A longitudinal study of group roles and system structure. In Burgoon, M. (Ed.), *Communication Yearbook, 6*: 925-944. Beverly Hills, CA: Sage.

Rogers, E.M. and D.L. Kincaid. 1981. *Communication networks: Toward a new paradigm for research.* New York: Free Press.

Snyder, H. and H. Rosenbaum. 1999. Can search engines be used as tools for web link analysis?: A critical review. *Journal of Documentation, 55*(4): 375-384.

Stefik, M. 1999. *The internet edge: Social, technical and legal challenges in a networked world.* Cambridge: The MIT Press.

Terveen, L. and W. Hill. 1998. Evaluating emergent collaboration on the web. Presented to the Conference of Computer Supported Cooperative Work, Seattle, Washington.

Thelwall, M. 2001. Commercial web site links. *Internet Research: Electronic Networking Applications and Policy, 11*(2): 114-124.

Tseng, S. and B.J. Fogg. 1999. Credibility and computing technology. *Communications of The ACM, 42*(5): 39-44.

Vedres, B. and D. Stark. 2001. The [Hungarian] Internet economy – A network approach. Presented to the International Sunbelt Social Network Conference, Budapest, Hungary.

Wasserman, S. and K. Faust. 1994. *Social network analysis: Methods and applications.* Cambridge, NY: Cambridge University Press.

Watts, D. J. and S.H. Strogatz. 1998. Collective dynamics of `small-world' networks. *Nature, 393*: 440-442.

Web, E.J. 1966. *Unobtrusive measures: Nonreactive research in the social sciences.* Chicago: Rand McNally.

Wellman, B. and S.D. Berkowitz. 1989. *Social structures: A network approach.* New York: Cambridge University Press.

Abstracts

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2002 Sunbelt Abstracts

Keynote Lecture

Social Networks, Social Space, Social Structure

Philippa Pattison

In this paper, I discuss the relationship between conceptualisations of social networks, social space and social structure. I argue that social space is an overarching and critical construct for a quantitative social science, and I suggest that there are two key theoretical concerns in specifying the nature of social space. The first is that social space cannot be specified simply in geographical, network or socio-cultural terms; rather, it requires an understanding of the interdependence of these different types of entities. The second is that social space cannot be regarded as fixed: unlike the Euclidean space of Newtonian mechanics, social space is constructed, at least in part, by the social processes that it supports. A general quantitative framework that addresses these two concerns is presented. Social network and other relational ties are constituent elements of social space within this framework, and social structure includes the patterned regularities in relations among these spatial elements. Applications of the approach illustrate its potential for a quantitative social science and also demonstrate connections with a number of theoretical claims about the localised nature of social phenomena. I finish by outlining developments that allow us to develop more precise models of social and psychological processes in both social space and time.

Plenary Lecture

A Two-Way Street: Interdisciplinary Research on Networks

Duncan Watts

Traditionally, social science has been the beneficiary of concepts and techniques derived from the natural sciences, such as mathematics and statistics, physics, and biology, but rarely have they returned the favour. The field of network analysis, however, is showing some promise of becoming an exception to the rule. While many of the early ideas of social network analysis (density, centrality, random-biased networks, block-modeling), had origins in mathematics and solid state physics, and a number of recent advances in network research (modeling of partly-random networks, non-normal degree distributions, dynamical evolution of networks, and network models of contagion) have come from outside sociology, it is also true that ideas and empirical evidence from sociology, particularly with regard to social networks, have begun to penetrate other disciplines. In this talk, I argue that social network analysis, properly construed, provides us a rare opportunity not only to adopt ideas from the natural sciences to address sociological problems, but to help natural scientists apply sociological ideas to their own problems. As an example, I follow the history of a single problem—The Small World Phenomenon—from its origins as an exclusively sociological question to a veritable cottage industry in statistical physics and other fields. Furthermore, while a few of the general features of the original research are well known, I show that the small-world phenomenon is still yielding insights which shed light on emerging problems such as efficient search algorithms for peer-to-peer networks.

Plenary Lecture

Nagging Issues in the Study of the Role and Meaning of Social Network Influence: Lessons and Potential Directions from a Case Study in Mental Health Care

Bernice Pescosolido

Social network theory and research has received wide acceptance over the last twenty five years across a wide range of discipline and areas of investigation. Yet challenges continue to confront and question the progress made to date. Particularly in the area of health care, the idea that social network influence shapes the recognition of, response to, and even occurrence of illness has taken a central place in research agendas. Yet, much research that mentions social networks takes great liberty in how concepts and measurement are employed. Focussing on the issue of how family networks affect whether and how providers and advisors are activated across healing systems, I raise, discuss and provide some empirical evidence to bear on four critical points relevant to ego-centered investigations. First, can we examine patterns of network activation as solutions to problems? Second, does the role of network influence exist simply as "norms" as depicted in many theories of decision-making or does influence require actual interaction? Third, does the current tendency to focus on single characteristics of network ties underestimate the importance of social networks and, even more critically, ignore the holistic impact of network configurations? Fourth and finally, to what extent does a structural approach to social networks need to take into account social psychological, psychological and even biological factors that facilitate or dampen the impact of social interactions?

Telecommunication and Internet as Globalizing Agents

Network Analysis Of Global High-Tech Flows. Does The Internet Change The Picture?

Teodora Erika Uberti

The aim of this work is to analyse two relevant complementary phenomena: globalization and international trade of high-tech goods. This recent globalization wave is characterized by the role of ICT, the rise of R&D intensity in production processes and the development of intra-industry trade. Social network analysis techniques will be used to evaluate these dynamics. Our sample includes about 40 countries, all OECD and their major reporting countries, and trading relations on high-tech goods and traditional manufactured goods, observed in early '70s, '80s, '90s and at the end of '90s. Interesting results emerge by adopting absolute and relative perspectives to evaluate the adjacencies matrices, and including the attributive role of apparent consumption, "reflexive ties", to identify supplier-countries (innovative and imitative) and demand-countries.

Indexes referred to nodes, to groups of nodes and to the entire networks are used to synthesize the structure and the evolution of these international trading systems. The main empirical results of these analyses are as follows. The densities of networks augmented over time to confirm the consolidation of an economically integrated globe; US maintains its trading leadership in production and in consumption, especially for high-tech goods; and a dynamic exchange structure, including countries (like Japan and NICs) and groups of countries (like European Union), is emerging at different sectorial-levels. Finally other statistical network methods, like QAP correlation and p*-models, enable an empirical analysis of the relation among the Internet diffusion, economic performance and activities location. The Internet, thanks to lower communication, transmission and storage costs, may transform the world into a completely connected network, maximally dense and minimally centralized. But reality seems rather different. The Internet infrastructure, localized hosts and backbones, and distinct telecom policies, as well as linguistic obstacles, preserve the difference between "geographical localization" and "geographical distance" within the "world-wide" network.

Science and the Internet in South India

Wesley Shrum, R. Sooryamoorthy & Theresa Davidson

Three general arguments on the role of the Internet in developing areas have been suggested. The "elixir" argument holds that the Internet does not represent a potential problem but only an opportunity. Information technologies are a developmental tool on a par with educational and agricultural programs. The "affliction" argument holds that Internet diffusion is an engine of global inequality, an insidious form of dependency creating new technology gaps between rich and poor, professionals and labourers, urban and rural dwellers, English and non-English speakers. The third argument holds that there are temporary "teething troubles" that may arise from telecommunications infrastructure or cultural differences that will soon diminish. We describe a project to examine the rapid introduction of the Internet in the south Indian State of Kerala. The "Kerala Model" is unique in the developing world owing to its combination of high social development with low economic development. Using qualitative data from interviews with scientists in universities and governmental research institutes, we examine early views of the effects of the Internet on the globalization of science and its impact on communication within and across national boundarieS.

A Longitudinal Analysis of the International Telecommunications Network 1991-2000

George A. Barnett & James A. Danowski

This paper examines the changes in the structure of the international telecommunications network during the 1990s based on the frequency of interaction among 39 major nations. The results indicate that the rate of change within the network may be best described by an exponential equation. This suggests that the telecommunications network may be a complex system. Historically, since 1980, the overall telecommunications network has been characterized as a single group that has becoming increasingly dense, centralized and more highly integrated. However, since the middle 1990s, there has been a reversal in these trends. An examination of the 1999 data suggests that the network may be fragmenting into three groups, one centered about the United States, another about Russia, and a third composed of Islamic countries. This may represent indicator that the network is a complex or self-organizing system.

The Impact of Globalization on Global Telecommunications Networks

Peter Monge & Sorin Matei

This paper provides an empirical test of Held, et al's (1999) theory of globalization. Held's work theorizes globalization in terms of the extensivity, intensivity, velocity, and impact potential of economic, cultural, and political networks. Held's theory is tested in light of the Monge and Contractor (2001) MultiTheoretical, MultiLevel Model which explains networks in terms of three levels: The endogenous characteristics of the focal network, the attributes of the nodes, and the properties of other networks or of the same network at earlier points in time. The focal network for this research is the 1999 worldwide telecommunications flow among 190 countries. Exchange and Balance theories are use to predict the level of mutuality, cyclicality, and transitivity in the network as indicators of increasing globalization. Attribute predictors include level of democracy, economic development, and level of globalization for each nation in the network. Data from telecommunications flows in 1989 are also used as exogenous predictors of the focal network. Data are analysed via p* logit regression techniques using the MultiNet computer program. Initial results, which will be further explored by the time the paper is given, reveal increasing levels of mutual ties in telecommunications flows between 1989 and 1999. More interesting, flows between countries blocked into high, middle, and low levels of democracy, economic development, and globalization have shown increased mutuality while those within similar blocks (e.g., same level of democracy) have not. Further analyses and implication of these findings will be presented.

Cognitive Networks: Concepts and Categories

The Structure of Meaning

Jaap Kamps, Maarten Marx & Robert J. Mokken

We use a network approach to meaning based on the WordNet

lexical database. WordNet is inspired by psycho-linguistic and computational theories of human lexical memory. Representations in WordNet are not on the level of individual word forms, but on the level of word meanings (lexemes). A word meaning, in turn, is characterized by simply listing the word forms that can be used to express it in a synonym set (synset). Hence meaning in WordNet is a structural notion: the meaning of a concept is determined by its relative position in the network of synsets.

We consider a simple graph *G(N,M)* with *N* the set of all synsets, and *M* the set of edges, such that two different synsets are adjacent if they share a common word in the same syntactic category. In WordNet, there are no synset relations between different syntactic categories or part-of-speeches (i.e., nouns, verbs, adjectives, or adverbs). We consider both the total graph *G* as its disjoint subgraphs of nouns, verbs, adjectives, and adverbs. The resulting massive graph *G* has 109377 nodes and 118020 edges.

We report a number of characteristic network results; e.g. the degree sequence of the graph satisfies a power law distribution familiar from real networks like the Internet, cellular networks, or collaboration graphs. There is a single giant component in each of the three subgraphs of nouns, verbs, and adjectives. This is in line with results from the theory of random graphs showing edge density (*M/N*) driving the emergence of a giant component. We analyse these giant components by multidimensional analysis and attempt to find intuitive interpretations of the multidimensional space. The giant adjective component can be related to the bipolar-adjectives studied by Charles Osgood in the 1950's for measuring emotive meaning.

The Duality of Statements and Speech-Acts: Dynamic Network Analysis of a Discursive Innovation

Peter Csigo & Balazs Vedres

The main question of this paper is that how innovations occur in political discourse. For mapping this we have chosen a case where opportunities for innovations in economic policy discourse were given by profound changes in the economy. We apply a Bourdieuian model that treats political field as "the site in which, through the competition of agents who are involved in it, political products, issues, programmes, analyses, commentaries, comments and events are created – products between which ordinary citizens ... have to choose". In our discourse, the structure of competing political products means the structure of competing "symbolic positions", "forms of knowledge" offered for the society about social-economic standing. What is at stake is to define the limit between "thinkable" and "non-thinkable." We have collected articles from three major dailies in Hungary for four months (from March 1997 to June 1997). We model this discourse as a two mode network of discoursive elements (statements) and speech acts (instances in the press when politicians or journalists link statements). We construct a two mode blockmodel of this network, blocking structurally equivalent statements into frames and structurally equivalent speech acts into positions. We test the robustness of this network by omitting speech acts of the most important actors and by recoding the statements.

Since each speech act has a date, we can chart the dynamics of positions taken over the four months of the discourse. Over the period studied government actors successfully transited from defensive to offensive by a discoursive innovation of taking up a new position that reaches across frames. The journalists of one daily have joined the government side writing editorials from within this new position, that helped in boosting the popularity of the government side. The opposition could only resort to radical stigmatization of the government side.

Using Network Analysis to Extract and Analyse Self-Presentation Strategies in Texts

Eleanor T. Lewis, Jana Diesner & Kathleen M. Carley

Extracting and representing the networks of ties between concepts in a set of texts creates a "map" of each text. Using map analysis, a researcher can systematically reduce the words in texts, then extracts and compares the networks of ties between concepts. In this paper we will present map analysis results that attempt to capture the self-presentation strategies authors use in their texts. Managing issues of self-presentation is a central goal of many different types of texts. Our research focuses on interpreting self-presentation strategies from map analysis networks that are created using different coding and data reduction techniques. We use an automated text analysis program (AutoMap©) to extract the concepts in the text, link them into statements based on their proximity in the text, and then into networks of statements within the entire text. The texts we study are a set of applications on behalf of entrepreneurs for an "Entrepreneur of the Year" award. The author's specific strategic intent in the text is reflected in different statements formed from the concepts in the text and the arrangement of those statements. Applicants value uniqueness in their application's content because it sets them apart and demonstrates their worthiness for the award, but the value placed on uniqueness in the structure of their strategic accounts is not as clear. Our analysis of the structure of concept networks in the text leads us to extract four general self-presentation strategies: the prepared entrepreneur, the driven entrepreneur, the creative niche entrepreneur, and the humble entrepreneur (a single entrepreneur may employ multiple strategies).

Software

Network Analysis with MultiNet

Andrew Seary & William Richards

We present an overview of the various network tools that are part of MultiNet. These include identification of strong and weak components, pruning trees, identification of various types of partitions, and four types of spectral analysis. We describe hybrid methods which allow creating node variables from networks, such as eigenvectors, partitions, and various centrality measures. We also describe methods for creating link variables from node attributes, and groupings of link variables. Throughout, we use real network data to illustrate procedures, methods, and results.

STOCNET in Development - An update

Mark Huisman, Tom Snijders & Peter Boer

StOCNET is an open software system in a Windows environment for the advanced statistical analysis of social networks. It provides a platform to make a number of statistical methods, that are presently still privately proposed but publicly circulated (such as SIENA, p_2, p*, BLOCKS, ZO), available to a wider audience. A flexible and easily accessible data structure and user interface are developed such that new methods can easily be included in the future. As such, it will allow researchers to de-

velop new statistical tools by combining their own programs with routines of the StOCNET system, providing a faster availability of newly developed methods. The StOCNET software can be downloaded from http://stat.gamma.rug.nl/stocnet. In this presentation we show the current state of the developments with an emphasis on the implementation and operation of the programs that already included: BLOCKS (for stochastic blockmodling), SIENA (for analysing repeated measurements of social networks). Moreover, we present an overview of future contributions, which will be available within a few months, if all goes well: p_2 (for estimating random effects models for binary adjacency matrices with actor covariates), PACNET and PALNET (for constructing a partial algebra for networks and local networks, resp.), and ZO (for the analysis of adjacency matrices with given marginals). Also an overview of planned activities with respect to the functionality of the StOCNET software will be presented.

The Use of Open Source Software for Social Network Analysis and Visualization

Jonathon Cummings & Carter Butts

With advances in open source software (e.g., Linux, Apache, MySQL, PHP), social network researchers have new opportunities for analysing and visualizing their data. For example, social network analysis routines have been developed for the R statistical language (http://legba. hss.cmu.edu/R.stuff /) and 3-D structures can be visualized online through the NetViz Module (http://www.netviz.org/). However, as software developers build more freely available tools, it is increasingly important to create standards that ensure compatibility across computer platforms, operating systems, and data formats. This paper compares some of these early stage open source programs with more robust and established software programs, Focussing primarily on their advantages and disadvantages. Implications are discussed for a social network community around the development of open source software.

Networks on the Web: Web Structures

Getting the Scoop: Social Networks for News Dissemination

Cameron A. Marlow

The "weblog" is a recent phenomenon, essentially an online journal of an individual's activities, news, and thoughts presented in a public manner on the web. Simple software tools for creating weblogs have allowed for a low barrier to entry, attracting men and women from a broad range of ages and occupations. In addition to creating these ego-websites, webloggers comprise a densely interconnected social network of readership that spans the entire set of nearly 400,000 persons.

This social network facilitates a dissemination of information through the community, allowing stories and news to reach a directed audience in an unmediated fashion. Sometimes particularly resonant news can reach a majority of the population in only a few days. These "memes," or viral information are generally associated with some external web resource and are easily identified by a URL.

We have constructed a system to track memes within the weblog community. As a meme diffuses through social ties, our system documents the time and location for each posting that is observed. Based on these data, webloggers can be categorized by their adoption characteristics, ranging from early- to late-adopters.

The weblog community is a fixed population that is constantly being exposed to new ideas. By associating the social network with data acquired for memes, we are able to study dissemination in a number of different cases. This breadth of examples is a longitudinal representation of how a community reacts to the spread of information. In this paper we explore network characteristics of the weblog community, Focussing on personal adoption behaviour and classifying memes based on their diffusion attributes.

Visualization of Web Browsing Behaviours Using Social Network Analysis

Hichang Cho, Jae-Shin Lee & Geri Gay

Visualization of web browsing behaviour has been one of key issues of the analysis of online activities (Eick, 2001). Using tools and methods in social network analysis, we 1) visualize clickstream data of 50 students showing how individuals navigate through a number of different websites, and 2) investigate the structures and paths of information flow among those URLs. Using a proxy server logon file of 50 students, we create a network diagram of top 100 URLs in which nodes represent URLs, and links between nodes represent clickstreams between the websites. The strength of link (network tie) is measured by counting how many times individuals visited both the sites in a given day or session. In addition to the visualization of clickstream data, a number of statistical analyses are followed to investigate the structure of URL networks including:

- Cluster analysis to explore what kinds of websites can be grouped together and to define the characteristics of each cluster based on the results.
- Auto-correlation tests to see if there are any meaningful differences in web browsing patterns in terms of gender, major, time, etc.
- Network role analysis of different websites using their network properties (e.g., centrality, betweenness, etc.)

What Can We Learn from Hyperlink Networks? Overview and Issues

Han Woo Park

Recently, there has been a surprising growth of hyperlink network studies in the Internet research community. Hyperlink research has examined social (or communication) structures among actors (individuals, organizations or nation-states) on the web. This paper reviews prior research on the topic and addresses these issues:

- What have studies of hyperlink networks told social network analysts about the nature and role of hyperlinks? Can hyperlink networks be regarded as social networks?
- How does hyperlinking affect the ways actors form social networks in cyberspace as well as in physical world? How do hyperlink relationships articulate wide-ranging offline (or other online) ties?
- What are the determinants and consequences of inter-website hyperlinks in terms of social networks? What is the cause and effect of the formation and maintenance of hyperlink networks among websites?
- What are methodological issues hyperlink analysts face? What does all centrality measures (such as in/out degree, betweenness, and closeness) tell us? Are they the reliable indicators of credibility, reputation, authority, or quality contents?

Searching for Information on the Web Using the Accumulated Knowledge of Others

Michael Weiss

More information is available today than ever before. The Web, in particular, provides access to a seemingly countless number of information sources. Search engines were intended to help the user locate web sites and information of interest. However, they suffer from the problem of returning an overwhelming number of search results, frequently including documents of marginal or low relevance, limiting their usefulness. One contributing factor is that search engines fail to consider a measure of user interest in their searches. In our approach to this problem, we propose a community-guided system for navigating the Web based on peer recommendations. Its unique contributions are a multi-agent architecture which addresses some of the scalability issues of traditional recommender systems, and a hybrid approach that combines searching with browsing, and delivers the search results incrementally in the form of annotated web pages. Our system recommends links to follow on a web page based on the browsing behaviour of other users with similar interests. The strength of this approach is that it exploits the accumulated knowledge of a community of like-minded individuals. Initial experiments indicate that it considerably reduces the information overload associated with current search engines, while better supporting serendipity, providing assistance when the user is browsing the Web. We evaluate how well our system addresses major open issues of recommender systems. How does the system obtain the user's preferences? How well is the privacy of users preserved? Can the system deal with user interests that change over time? How good is the quality of the search results? How scalable is the system, given the highly distributed nature of the Web? We also present empirical evidence from building a limited-scale prototype.

Large-Scale Networks: Models and Sampling

Predicting the Spatial Structure of Large-Scale Interpersonal Networks by Means of Extrapolative Simulation

Carter T. Butts

Empirical studies of interpersonal networks demonstrate a strong relationship between physical distance and edge probability. Bayesian analysis of the edge probability/distance relationship for several classic data sets is used to identify maximum probability (posterior mode) models for various interpersonal relations. Extrapolative simulations based on the posterior mode are subsequently used to explore the implications of these models for the structure of large-scale interpersonal networks. Emphasis is placed on the prediction of explicitly spatial properties of network macro-structure (e.g., the variation in local tie volume across physical space) using data drawn from Tobler et al.'s (1995) gridded world population data set.

The Role of Infinite Graphs in Network Sampling

Ove Frank

In ordinary survey sampling of multivariate populations with no network structure it is customary to distinguish between design based and model based statistical inference. The design based approach treats the population as a finite set of individuals with fixed values on the variables and specifies selection probabilities for all possible samples of individuals. The model based approach ignores how the sample was drawn and specifies a probabilistic model for how the population values are generated. An important role in this context is played by multivariate normal distributions describing infinite populations from which the actual population values are drawn. When there is network structure present in the population, a similar approach can be applied which is based on the concept of an infinite graph. This possibility is discussed and, in particular, specific multivariate normal distributions are introduced as network models that can be conveniently analysed by regression methods.

Does Network Size Matter?

Christopher McCarty, H. Russell Bernard, Peter Killworth, Gene Shelly & Eugene Johnsen

With some exceptions, the analysis of ego network data are typically attribute-based – that is, the attributes of alter characteristics are aggregated and used as attributes of respondents, along with standard socio-demographic variables. Attribute-based analyses, while both useful and powerful, cannot capture the effects of variability in network structure on individual attitudes and Behaviours. By asking respondents to evaluate the existence of ties between each of their alters on a relatively large sample of alters (n>30), we can aggregate structural variables to the level of respondents as well. This allows the researcher to examine such questions as how network density and centrality differ by sex, income or race. Ego-centered network structural data are unique in that they capture the structural effects of membership across groups. The data consist of 46 proximity matrices elicited from 46 respondents who each free-listed 60 alters and provided an evaluation of all 1,770 ties between the 60 alters. The number of alters was fixed to insure comparability of all structural measures, many of which vary depending on network size. Random checks of inter-alter tie evaluations demonstrate the ability of respondents to report these data reliably. The current research looks at the variation of network centrality in ego-centered networks. It is found that with a large sample of alters, different centrality measures vary considerably across respondents and socio-demographic variables. There is also a pattern of the placement of central alters from the free-listing task. It is hoped that this analysis will demonstrate the power of structural analyses of ego-centered network data with large, fixed sample sizes.

Scholarly Networks

Scholarly Holes? The Effects of Citation Structures Upon Citedness

Iain Lang & Alan Buckingham

Previous work has shown that social scientists tend to make citations to, and hence build upon knowledge from, networks of texts that already form closely-connected networks; it is part of normal science for the production of scholarly knowledge to proceed in this way. Sometimes, however, writers bring together knowledge from more diverse sources, and may be seen to connect their work to that associated with more than one such previously-existing network. It has been argued that such deviations from typical citing practice—that is, from the norms of science identified by Merton—are important for the progress of science. On the other hand, writers

who fail to conform to the usual patterns of citation-usage and knowledge-use when working in a particular subject-area may be seen as producing work that is effectively unacceptable, and such work may risk going uncited and becoming forgotten. Focussing on work that deals with the much-argued-over subject of the social 'underclass', this paper represents a preliminary examination of the effects of different structures of citation. Are texts that refer to a more focussed range of previous works more likely to themselves be cited? What level of risk is being taken by writers who refer to previous work more broadly rather than in a more focussed way?

How do Software Engineers Envision their Field? A Comparison of Author Cocitation- and Knowledge Elicitation-based Structures

Katherine W. McCain, June M. Verner, Gregory W. Hislop, William Evanco, & Vera Cole

As part of an extensive domain analysis of Software Engineering, we used Author Co-citation Analysis to map the field based on the citations to 60 prominent authors over the period 1990 - 1997. We identified 8 author clusters arrayed along two dimensions--"programming in the small" to "programming in the large" and a continuum of interest reflecting more or less "formal" content of their work. We also used a standard knowledge-elicitation method, card sorting, to obtain perceptions of the 60 authors and their work from 46 practising software engineers in academia and industry. The aggregate card sorting tallies were mapped and clustered. Comparison of the two structures reveals interesting similarities and differences between the way that authors in Software Engineering are perceived and the way their work is used in scholarship and research.

Social Support

The Network of Domestics Units and Public Organizations in Vic (Barcelona)

José Luis Molina

In this paper we analyse examples of reciprocity in a town of Catalonia among two collectives related to the Social Welfare Department: aged Catalan people and Berber people immigrated from Nador, Morocco. From a network analysis perspective we propose: a) to differentiate between social exchanges (those exchanges that create social debts, that is, the obligation to reciprocate) and economic and administrative exchanges, balanced in theory, and b) the usefulness of taking the network of domestic units and their exchanges as the unit of analysis. Although the research is in the beginning we have found that reciprocity can be conceptualized as a social exchange naturally attached to domestic sphere but embedded and regulated in the market and Public Administration spheres (as cartel and corruption respectively). To account reciprocity today implies an analysis of the social exchanges in the three domains.

A Cultural Model of Social Support

Susan C. Welder, F. Dalo & A. DiNuzzo

Social support involves the availability of people for assistance, emotional concern, and information. The NORC-GSS social support module contains six scenarios covering situations in which someone might need help such as: help with household jobs, help around the house if you were ill, needing to borrow a large sum of money, problems with spouse/partner, feelings of depression, or needing advice about an important life change. Examining responses to those questions in national surveys, Freeman & Ruan (1997) found high consistency in aggregate patterns of reported support across several countries. In Brazil, Dressler et al (1997) found that differences in social support "role expectations" and available support was adversely associated with health. This study examines community beliefs about sources of support as a first step in studying differences between cultural expectations for social support and social support received by individuals. Initial open-ended interviews (n=24) exploring social support, found that the most frequently mentioned themes corresponded with those captured in the NORC vignettes, with the exception of two additional scenarios: caring for a loved one and having problems at work. Then a sample of community members (n=60) was interviewed about who should provide support for the eight scenarios. For each scenario, nine choices were ordered from most to least desirable. Cultural consensus analysis indicated that there was sufficient homogeneity in the orderings across the subjects to conclude that there is a single, shared set of beliefs about ideal patterns of social support. Preferred patterns are similar to the aggregate national patterns found by Freeman & Ruan, but with a much stronger preference for the "spouse" to be the desired source of support for most needs, followed by parents, and siblings.

Gender, Spousal Relationships and Well-being

Matthew Dupre & Amelie Quesnel-Vallee

It is well known that marriage is negatively related to psychological distress. This is in part explained by the protective function of the spousal relationship. It is also well known that women are worse off psychologically than men. The question, then, is whether there is also a difference in how men and women perceive or experience their spousal relationships and whether this relationship differentially affects the psychological well-being of women and men. The confirmation of this gender effect in spousal relationship could help clarify the gender difference in psychological well-being as well as in differential marital effects. Further, it will also point to directions in future research Focussing on the differential network functions of marriage for men and women. We examined these patterns in a longitudinal community study conducted in upstate New York in 1993-1994 and found strong confirmation of the relationship between naming spouse as a confidant, as well as spousal relation-ships, and psychological well-being. Also, married men were much more likely to name their spouses as confidant or claim better spousal relationships as compared to married women. We speculate that men have access to more extensive and diverse resources embedded in their social networks and, thus, women tend to rely on their spouses as bridges to access resources. This inequality in network resources and power explain in part the differential effects of marriage on psychological well-being for men and women.

Managing Intraorganizational Networks

ICT Starters and their Networks: Search and Support in Building New Firms

Tom Elfring & Wim Hulsink

The value of networks as an integral part of the explanation of entrepreneurial success is widely acknowledged. However, the network perspective lacks specification of the various dimensions of a network and their impact on the early development of a new

venture. The question of this paper is: "In what way does the entrepreneur's network contribute to the success of the starting company." The network is important because it may contribute to the ability of the entrepreneur to discover opportunities, to get resources, and to gain legitimacy. In the literature it is unclear in what way certain network influences the success of a start-up company. In some industries firms with a dense network structure and strong ties appear to be more successful than firms without a dense network structure and weak ties, while in other industries it is the reverse (Rowley et. al, 2000). The network contribution to a start-up may, however, be negative as well as a result of network overload. This research is intended to clarify the contingencies of the network contribution to the success of the starter.

We constructed the networks of 30 ICT start-ups in the Netherlands on the basis of company documents and interviews with the founders. A distinction was made between three types of initial network conditions. First, start-ups in incubators; secondly, spin-offs from established companies and lastly, the more or less independent start-ups. For each of these categories there were at least two failures in our sample. On basis of the variations in the structure of the network and the type of (critical) relations we intend to develop propositions concerning the contribution of a particular network configuration to the ability of the start-up to discover opportunities, to get resources and to gain legitimacy.

Project Management Coalitions: Measuring Changing Roles Through Comparative Centrality

Stephen David Pryke

This paper proposes that coalitions of firms that collaborate to form project teams can be conceptualised as networks of actors linked by three types of relations. These are communications, authority and financial incentives. Furthermore, it is proposed that it is useful for the communications network data to be gathered according to the principal functions of the project management coalition. In our case, these were cost management, time management and design management activities. We commence with a very brief critique of some of the alternative methodologies available for the analysis of project coalitions, particularly in relation to major capital projects. We present data gathered from four major UK projects; two public sector and two private sector. It is proposed that the centralities for the actors within the main groups of activity areas in the project coalition and which relate to the three aspects of project governance being studied (communications, authority and financial incentives) can be represented in a comparative centrality triangle. The data presented in this way provides a measure for changing organisational roles, as well as a measure of maturity of those roles. The paper therefore proposes a social network analysis based methodology for the study of changing and emergent roles in project coalitions. A means of graphically presenting these changing roles has been developed that is theoretically robust but yet provides simplicity and clarity and which would have application in research and consultancy work.

Intra-Organizational Social Networks and Work Processes

Hallie J. Kintner, R. Jean Ruth & Mark Beltramo

Much remains to be learned about the role that social networks play in work processes, especially for white-collar workers. This paper reports on a study that used both ethnographic and social network approaches to studying work processes. The study examined work at the very beginning of the product development process at a major automotive manufacturer. The study discusses the advantages and disadvantages of this multi-method approach. It also examines the composition of the social network and what it reveals about the underlying work processes.

Networks in East Asia: China and Taiwan

The Types, Characteristics, and Influences of Adolescent Friendship Network

Chyi-In Wu

This study examined Taiwanese adolescent's friendship network. The main foci are on adolescent friendship network's types, characteristics, and its long-term outcomes. References have showed that closer relationships with other youth are predictive of lower resilience and greater vulnerability to risk, however, the pathways of friendship network influences are still not well realized. This study contributes to an understanding of the less understood "off-diagonal" pathways and their sequence of transitions. Data used in this study is extracted from a panel study, which were conducted by the author beginning in 1996 through 1999 in Taipei. This is a school-based study of the health-related behaviour adolescents originally in grades 7. It has been designed to explore the causes of these Behaviours, with an emphasis on the influence of social context. The study interviewed about 1,500 middle high school students (at first wave, they are all on the 7th grade, age 12-14) and their mothers and main teachers. Data were collected from adolescent respondents on best friends; the clustered sampling design generates many pairings for which both participants are respondents. This allows, for example, for the analysis of peer influence, the process of pair formation and dissolution, relationship event sequencing, and a relationship symmetry. Based on doing social network analyses on an Internet-Based Social Network Analyzer, which developed by the author and his colleagues, the findings show that there are at least 7 types of friendship networks that all own different durability and continuity. "Lonely birds," who have been isolated from any type of friendship networks in earlier adolescence, are facing the highest risk that lead to unhealthy, self-destructive Behaviours in the later adolescence.

The Mechanisms of Job Matches in the Career Mobility for Men and Women Manufacturing Employees in Taiwan: The Significance of Social Networks and Human Capital

Ray-May Hsung & Esther Ngan-Ling Chow

We used 382 men and women employees with at least two times of job change in 9 factories of Taichung Industrial Park and Export Process Zone. This study was not only concerned about how the individual characteristics (gender and education) and the organizational characteristics affected the job search methods for the first and the current jobs, but also was concerned about the outcome of job matches. Our findings indicated that men and women did not show significant difference in terms of job search methods and the outcome by different means of job matches; however, the differences of job matches and their outcomes between men and women employees were getting significantly bigger along the career mobility. For the first job match, employees with university graduate degree or matching with larger scale of factories tended to have greater probability to

take market channels to seek jobs, and gender did not have significant effect on the job match methods. The occupational prestige attained through weak social ties tended to be lower than those attained through market channels for men employees. However, the job search methods did not have any significant effects on the attained occupational prestige of the first job for women employees, and the human capital was still the important factor for the first job match. For the current job match, the human capital effects on job search methods declined and became not significant, but gender effect became significant. Women tended to use personal networks to seek jobs. Another interesting fact is that there was a path dependence effect in terms of job search methods for both men and women employees. The employees by means of personal networks to search for the first jobs had greater probability to seek current jobs through personal networks. Finally, the function of human capital and social capital on job matches along the career development and the reproduction of gender inequality will be discussed.

Networked Entrepreneurs in China's Private Business

Wenhong Chen

The re-emergence and repaid growth of private enterprises in transitional countries have profound impact on the reconfiguration of social structure and the process of social transformations. Students of Economic Sociology have acknowledged that the entire process of entrepreneurship relies on resources accessed and mobilized through social networks. Earlier studies on transitional countries indicated that political elites based on formal positions or informal networks easily converted political capital into economic advantage, which gave rise to the phenomenon of "power conversion" or "political capitalism"(Rona-Tas, 1994). Nevertheless, more recent research highlights impressive success of entrepreneurs from less privileged backgrounds (Gil et al. 1998). Different from the "Big Bang" or "Shock Therapy" strategy in Eastern Europe, the gradual reform in China offers a unique opportunity to examine the dynamic interaction of entrepreneurship, social network, and processes of social transformation, where the powerful fist of the state is tangled with the invisible hand of the market. Drawing on the 1997 national survey of private business in China, this research is primarily interested in two questions: 1) how entrepreneurs from different socio-economic groups utilize network capital afforded by multiple networks, and 2) what kinds of characteristics of their network ties facilitate the access and mobilization of network resources. Moving beyond a description of " who are the entrepreneurs and where they come from" (Robert & Bulodi, 2000), I find that most entrepreneurs rely on network capital to establish and develop their business. Furthermore, I identify three dimensions of network capital that entrepreneurs could tap into through their social networks: assistance of starting up, networking, and participation in daily operation. I find that work organizations (Danwei) in which the entrepreneurs and their network ties worked or are current working, play a significant role in determining whether and what kind of network capital is available for private entrepreneurs.

Deviant & Criminal Networks

Estimation of Offending and Co-offending Using Available Data with Model Support

Ove Frank & Peter J. Carrington

Police data under-report the numbers of incidents and of offenders, the numbers of offenders participating in individual criminal incidents (incident sizes) and the numbers of incidents in which individual offenders participate (offender activity). We show that co-offending is a concept which underlies, and unifies, all of these phenomena, so that the numbers of incidents and of offenders, and incident size distributions and offender activity distributions, can all be derived from the co-offending (criminal participation) matrix. Two related statistical models are presented which permit the estimation of numbers of incidents and offenders, incident size distributions, offender activity distributions, and co-offending distributions, from police-reported crime data, and data on the reporting of crime to police. These models rely on simple probability mechanisms for incident reporting and identification of offenders. The models are estimated, using Canadian Uniform Crime Reporting Survey and victimization survey data for 1995-99, and offender activity data from the Philadelphia criminal careers study. The implications of the results of fitting the models are discussed, as are other data which might be used.

Bayesian Estimation of Offending and Co-Offending Using Covariates

Johan Koskinen

As discussed by Frank and Carrington (see above) many criminologists can testify to the difficulty in obtaining information on criminal networks. Typically, one works with police records and similar registers. For obvious reasons, the police are reluctant to release data on individuals and there is the additional complication that reported crimes, for example, do not necessarily have to reflect the actual criminal activity. Another source of information could for example be reports by the criminals themselves. Covariates and reports from criminals on the co-offending structure could be obtained through interviews. The aim would be to get as many versions of the co-offending structure, in its entirety, as possible. It would seem reasonable to assume that these reports then do not truthfully reflect "reality", rather we expect these reports to be biased, perhaps in a systematic way. Borrowing the general methodology from the study of cognitive social structures, we here propose a way of dealing with this bias. This is made possible by employing a probit model that we assume have generated data. Data would then consist of the reports as well as the other sources of information regarding the co-offending structure we might have. All information, together with known covariates, is incorporated in a Bayesian framework into an analysis that yields estimates of the co-offending structure as well as estimates of the influence of the covariates on the bias. The uncertainty about these estimates in given by the posterior distribution given data.

Model Based Co-offending

Jan Hagberg

In a Poisson-gamma mixture model we assume that the number of crimes each offender commit is Poisson distributed with parameter lambda. The parameter lambda is assumed to follow a gamma distribution. From the model we derive a set of parameter estimators related to the number of crimes committed by 1, 2 and 3 or more offenders.

A Multilevel Network Study of the Effects of Delinquent Behaviour on Friendship Evolution

Tom A.B. Snijders & Chris Baerveldt

A multilevel approach is proposed to the study of the evolution of multiple parallel networks. In this approach, the basic evolution process is assumed to be the same, while parameter values

may differ between different networks. For the network evolution process, stochastic actor-oriented models are used, of which the parameters are estimated by Markov chain Monte Carlo methods. This is applied to the study of effects of delinquent behaviour on friendship formation, a question of long standing in criminology. The evolution of friendship is studied empirically in 19 school classes. It is concluded that there is evidence for an effect of similarity in delinquent behaviour on friendship evolution. Similarity of the degree of delinquent behaviour has a positive effect on tie formation but also on tie dissolution. The last result seems to contradict criminological theories, and deserves further study.

Networks and Health

The Relationship Between Social Network Characteristics and Exchanging Sex for Drugs or Money Among Drug Users in Baltimore, Maryland

Carl Laktin, Wei Hua & Amy Knowlton

This study examined social network and drug use factors associated with buying and selling sex among a sample of opiate and cocaine users in Baltimore, Maryland. A sample of 702 drug users who were sexually active were administered a social network and risk behaviour inventory. Compared to 25% of men, only 1.67% of women reported history of giving money or drugs to get sex during the past 90 days. Conversely, more women (19.78%) than men (4.75%) sold sex for money or drugs. Those who sold sex were more likely to be low frequency crack smokers, were more likely to drink alcohol at least once a day, had a higher average number of crack-only smokers in network, and had a smaller number of kin in network. Men who exchanged money or drugs for sex tended to be low frequency crack smokers and reported having more crack-only smokers and injectors and less kin in their networks. The results suggest that network composition may be a risk factor for exchanging sex, particularly with respect to crack users, while kin may be a protective factor. These associations may be either a cause or consequence of exchanging sex.

Cruising for Truckers on America's Highways: Truckers' Male Sexual and Drug Networks and Disease Transmission

Yorghos Apostolopoulos

Despite demonstrated links between trucking and infectious diseases in developing regions, health repercussions of risk taking among U.S. truckers and their highway risk networks remain undocumented. While the application of a hierarchical classification of risks would impede a comprehensive understanding of transmission dynamics for trucker networks, this paper is guided by the hypothesis that truckers bridge population groups with significant structural equivalence at truck plazas, thereby facilitating infection propagation through the replication of the social context while driving across the U.S. This paper provides a theoretical discussion and empirical evidence of the role of truckers' sexual and drug networks and "truck chasers" (MSM who cruise for truckers at highway rest areas) in the acquisition and dissemination of STIs and BBIs. It constitutes a portion of a broader study that identifies extensive trucker risk networks in the U.S., comprised by a gamut of diverse populations, including: male and female truckers (heterosexual, homosexual/bisexual); female commercial sex workers ("lot lizards"); MSM ("truck chasers"); female "truck chasers;" pimps; drug dealers; "polishers;" interstate and cross-border migrant labourers; homeless; hitchhikers; truck company/plaza employees; sexual, drug, or other risk contacts at home settings; and other highway social, sexual, and drug contacts. Though preliminary findings from ethnographies and surveys have revealed the magnitude and multiplexity of truckers' networks, results for this paper are primarily based on a unique database including data on the sexual relationships of a single "truck chaser" who has documented contact with more than 2,400 truckers over 14 years involving over 4,100 sexual/intimate encounters. Analyses delve into the social organization of sexual risk taking and substance use patterns among male trucker networks as well as the sociocultural and physical contexts of these networks, within the framework of ascertaining trucker networks' role in disease transmission as well as delineating their configuration.

Psychiatric Treatment and the Sexual Networks of People with Serious Mental Illness

Eric R. Wright

Over the past decade, public health experts have become alarmed about the spread of HIV/AIDS among people with serious mental illness (SMI). This paper examines the sexual networks and associated risk behaviour of people diagnosed with and in treatment for SMI. The data for this study were collected as part of the Indiana Mental Health Services and HIV Risk Study, an ongoing study investigating the mental health system's response to the HIV-related needs of clients with SMI. In-depth sexual network interviews have been conducted with 414 clients (through 11/1/01) at three community mental health centres and two state hospitals in central Indiana. The response rate is 75.7%. The interview schedule asks respondents to nominate and describe all of the sexual partners they had in the past three months. The findings indicate that approximately half of the clients in community treatment and about one fifth of the state hospital patients were sexually active during the three months preceding the interview. While state hospital patients are less likely to be sexually active, they report having had significantly larger numbers of sexual partners and being more likely to engage in risky sexual Behaviours within those relationships. The sexual partnerships of community clients are generally monogamous relationships and involve safer sexual practices. This overall pattern suggests that the social organization of treatment is influencing the patterns and nature of HIV risk among clients with SMI. In particular, hospitalization and/or institutionalization may be contributing to the expansion of the HIV epidemic among people with SMI. The implications of these findings for the study of sexual networks and health and for mental health and public health policy are discussed.

Randomized Trial of Supplementary Interviewing Techniques to Enhance Recall of Sexual Partners in Contact Interviews

Devon D. Brewer & other authors

Previous organizational behaviour (OB) research tends to examine group performance by Focussing on the effects of individual traits or their aggregates. Although this line of research has contributed greatly to our understanding of group Behaviours and their effects on group performances, what has frequently been ignored is the structural context of groups — the group network of relationships that knits everyone into interactions.

The current study intends to explore the dynamics of groups and the determinants of group performance from an alternative view — the social network perspective. We first build a theoretical framework to examine the evolution of group network structures in terms of centrality and fragmentation and their effects on group performance, while interactions with group attributes identified in micro OB studies are also considered. We then conduct an empirical study based on a sample of 45 university student groups over a period of one semester. The results show that: a) group network structures do evolve over time but they are also influenced at the early stage by group attributes identified in previous research that are not static in nature; and b) group network structures can provide a stronger prediction for later stage group performance while group attributes can help predict performance at the early stage. Our study has demonstrated the importance of the social network perspective in understanding group dynamics. Implications of the findings for future research and practice are also discussed.

Centrality and Other Statistical Concerns

Centrality in Ego-Centered Networks

Chris McCarty

With some exceptions, the analysis of ego network data are typically attribute-based – that is, the attributes of alter characteristics are aggregated and used as attributes of respondents, along with standard socio-demographic variables. Attribute-based analyses, while both useful and powerful, cannot capture the effects of variability in network structure on individual attitudes and Behaviours. By asking respondents to evaluate the existence of ties between each of their alters on a relatively large sample of alters (n>30), we can aggregate structural variables to the level of respondents as well. This allows the researcher to examine such questions as how network density and centrality differ by sex, income or race. Ego-centered network structural data are unique in that they capture the structural effects of membership across groups.

The data consist of 46 proximity matrices elicited from 46 respondents who each free-listed 60 alters and provided an evaluation of all 1,770 ties between the 60 alters. The number of alters was fixed to insure comparability of all structural measures, many of which vary depending on network size. Random checks of inter-alter tie evaluations demonstrate the ability of respondents to report these data reliably.

The current research looks at the variation of network centrality in ego-centered networks. It is found that with a large sample of alters, different centrality measures vary considerably across respondents and socio-demographic variables. There is also a pattern of the placement of central alters from the free-listing task. It is hoped that this analysis will demonstrate the power of structural analyses of ego-centered network data with large, fixed sample sizes.

Generalizing Centralization to Core/Periphery Structures

Martin Everett & Stephen Borgatti

Recently Borgatti and Everett have proposed a centrality index which measures the degree to which an actor is in the core or the periphery of a core/periphery structure, they call this measure coreness. They also argue that eigenvector centrality is an example of such a measure. Related to centrality is the idea of centralization, a whole network measure which gives an index of the extent to which a highly central actor is surrounded by actors of low centrality. This can be generalised to the situation in which we measure the extent to which the network has a core surrounded by a group of peripheral actors, we call this generalization concentration. We examine and evaluate a number of different measures of concentration and show how these measures can be used to partition a network into a core and a periphery given a coreness score for each actor in the network.

Instability of Measures of Centrality and Prominence in Social Networks

Valentina Hlebec & Barbara Zemljic

This paper evaluates stability of measures of centrality and prominence of social networks among high school students. The authors present and discuss results from eight experiments. Four types of social support were measured three times within each class. Four measurement scales (1) binary, (2) categorical, (3) categorical with labels and (4) line production, as well as two measurement techniques for listing alters (free recall and recognition) were applied. Stability of in- and out-degree, in- and out-closeness, betweenness and flow-betweenness was estimated by Pearson correlation coefficient. Meta-analysis of factors affecting stability of measures of centrality and prominence was done by Multiple Classification Analysis. Results show that,

- global measures are more sensitive to measurement errors than local measures;
- in–measures are more stable than out–measures;
- among types of social support, emotional support gives the least stable measures of centrality and prominence, whereas social companionship gives the most stable results;
- when two network generators are presented within 20 minutes, the stability of measures of centrality and prominence is higher than the stability of two network generators presented within a week;
- the stability of measures of centrality and prominence is higher when line scale and categorical scale with labels or categorical with labelled extremes are used;
- stability of measures of centrality and prominence is lower when line scale and binary scale are used.

Segmenting the market according to consumer's benefits and value orientations — the application of structurally determined laddering method

Bojan Korenini and Zenel Batagelj

As marketing practice accepted the viewpoint that company does best when directing its activities according to the needs and desires of customers in chosen target markets, the necessity for the research methods that would increase the depth of understanding of the consumers emerged. The laddering research method counts as one of new approaches that are trying to fulfill this request. Although there are different approaches to laddering, the method originates in the field of qualitative methodology. Theoretically it draws from means-end theory that treats objects as means to achieving certain valued states, or ends. By using a series of directed probes, typified by the question "Why is this important to you" it identifies the specific linkages between product attributes, consumer benefits and consumer's

value orientations. The data create a hierarchical value map. Such map is treated as a directed graph, which shows a unique way in which a product is linked to consumer's personality. There are a lot of different quantitative and qualitative research methods that are aimed at exploring the relationship between the product and consumer's value orientations. In the case of quantitative research methods, there is a lack of information, how specifically different characteristics of a product fit into the consumer's life. On the other hand qualitative methods are better at revealing such information, but because of unstructured nature of such methods they are usually conducted on smaller samples. This fact qualifies them to explore just the respondents under examination rather then to be representative for the whole population of consumers. Laddering overcomes such problems. The method provides information about specific individual-based linkages between consumer product characteristics and consumer's value orientations. Because of structured gathering of the data, method can be conducted on larger samples. There are different approaches to laddering: soft laddering, hard laddering and structurally determined laddering method. The later was developed by the authors of this paper. Although one of the advantages of soft laddering method is that it can be conducted on larger samples, in practice sample size usually doesn't exceed 50 or 100 respondents, because soft laddering interviews are difficult and require specially trained interviewers. Besides identification of common structures in complex qualitative data is very labourious. Most frequently the type of marketing decisions where laddering method proves supportive require statistically grounded conclusions. The new approach - structurally determined laddering can be conducted on several hundred or more respondents (it can be also conducted over the phone). In this way conclusions of the laddering research are no longer limited to the sample of respondents under the scope. Beside that structurally determined laddering opens a lot of new possibilities, in the sense of analysis and practical application of research results, which depart significantly from the possibilities that soft laddering could offer. Authors of the paper wish to discuss different approaches to laddering method in the context of quantitative and qualitative research methods, statistical analyses of such network data and benefits that follow from the application in marketing, mainly in the field of market segmentation.

Hyper-edges and Multi-dimensional Centrality

Phillip Bonacich & Michael Johnston

Networks typically involve dyadic relations between two actors. However, there are occasions in which relationships have more than two principals. Some non-dyadic actions, for example, may require the coordinated actions of three or more actors rather than two: a buyer, a seller, and an agent, for example. Other principals can also be introduced when actions are fruitfully best described with the addition of characteristics other than the identities of the actors. For example, interactions may occur in certain places or at certain times. These additional characteristics can be as essential to the description of the act as the identities of the actors.

A hypergraph (Berge, 1989) with hyper-edges describes can be used to describe these more-than-dyadic situations involving either three or more actors or two actors plus some characteristics of the situation, like time or place. Using hypergraphs, a method of calculating eigenvector centrality when there may be more than three principals in a transaction is suggested and applied to data on attacks of Caribbean island natives on Spanish settlements between the years 1509 and 1700. The analysis produces centrality scores for native groups, years, and attacks.

Evolution of Interorganizational Networks

Evolutionary Processes and Paths of Embedded Network Ties in Emerging Entrepreneurial Firms

Julie M. Hite, Takeru Miki & Toru Ishida

For those who engage in intellectual occupations, such as researchers, constructing the good social networks is essential for their research activities. By utilizing the social networks, researchers can exchange important information, create new knowledge in concert, and sometimes establish new research area. The recent diffusion of various kinds of Internet applications promotes diversifying and expanding the social networks among researchers. In this situation, our work aims to clarify if the hyperlink structure of the WWW represents the scholarly networks and communities existing in the real world.

We obtained 10,455 personal web sites, that were managed by computer scientists engaging in several special fields, such as Artificial Intelligence, Software Engineering, Networking, and so on. The co-citation analysis was applied to these web sites, which were cited 14 times or more by other researchers. This selection criterion resulted in a pool of 102 computer scientists' web sites. In the co-citation analysis, principal component analysis with varimax rotation was used to extract factors. The result was mapped in two dimensions to grasp the structure of the scholarly communities existing on the WWW.

Three remarkable clusters that represented special fields in Computer Science were appeared: Artificial Intelligence, Programming Language, and Computer Architecture. We also found that the researchers who built bridges over the structural holes of these big clusters were the specialists of Cryptography and Information Security. In each cluster, researchers were not only highly co-cited, but also linked directly and densely each other. Even if we decreased citation frequency thresholds in order to increase the experimental subjects, we could confirm the same tendency. Therefore, this study clarified that the hyperlink structure of the WWW represents the social networks of researchers. The next step of this research is comparing the topology of Web-based scholarly communities to the literature-based (author co-citation analysis to the research outcomes such as conference and journal papers) communities.

The Dynamics of Network Strategies in the Canadian Investment Banking Industry, 1952-1990

Tim J. Rowley & Joel A.C. Baum

In this study, we seek to broaden the focus in the strategic alliance and networks literature from a firm's 'partner strategy' to its 'network strategy' by linking a firm's network moves – its partnering choices – to changes in its network position over time. Using data on all underwriting syndicates formed by investment banks in Canada over nearly 40 years, we conceptualize and model the interplay between a bank's and its partners' network moves. Our findings indicate that the partnering choices of 'lead' banks, which wield greater control over their network structure than 'co-lead' banks, are more likely to improve their network positions more than co-lead banks, and that lead banks compete with each other for brokering opportunities (i.e., structural holes). Our findings show that new insights into

the dynamics of inter-firm networks and the competitive advantage of firms are possible within this broader view.

Strategic Block Formation: A Closer Look at Factors That Enable and Enforce Block Formation in Strategic Technology Alliance Networks

Charmianne Lemmens

In this paper we will empirically test the factors that enable and enforce strategic block formation in strategic technology alliance networks. In particular, we will investigate the role of embeddedness and social capital as possible important driving factors in the process of strategic block formation. High social capital is suggested to lead to a higher propensity to engage in new partnerships. In particular firms in central network positions benefit from a high degree of social capital which makes those central players attractive partners. More specifically, we argue that firms in central network positions have a higher propensity to engage in subsequent ties and hence enable strategic block formation through local search. However, embeddedness, social capital and strong ties are not the only enabling factors for block formation. Further in this paper we argue that there are some other parameters which enforce the block formation process even more. These enforcing factors are discussed in terms of lock-in and lock-out effects and replication of existing ties.

Pathways of Property Transformation: Enterprise Network Careers in Hungary, 1988-2000

David Stark & Balazs Vedres

This study analyzes the restructuring of a national economy by identifying the career pathways of its enterprises. This analysis is conducted in a setting strategically chosen as a case of rapid and profound economic transformation: the post-socialist Hungarian economy between 1988-2000. The goal of this study is to chart the multiple pathways of property transformation. Property pathways are conceptualized as the patterned sequences of change that firms undergo 1) in the composition of their ownership structure and 2) in their position within network structures of ties to other enterprises. These career pathways are neither unidirectional nor plotted in advance. The landscape and topography of the socioeconomic field are given shape and repeatedly transformed by the interaction of the multiple strategies of firms attempting to survive in the face of variable political, institutional, and market uncertainties.

The core dataset includes the complete ownership histories of approximately 1,800 of the largest enterprises in Hungary for a twelve year period, starting with the collapse of communism in 1989, recording each change in a company's top 25 owners on a monthly basis. These rich data make it possible to map the life cycles of the business groups that are formed by network ties among enterprises, identifying not only when they arise, merge, or dissipate, but also the changing shapes of their network properties. To identify patterns of change, the study draws on sequence analysis, a research tool that makes possible the study of historical processes in an eventful way similar to historiography while retaining social scientific abstraction. Whereas sequence analysis has given us a perspective on careers as historical processes but has not been applied to business organizations, network analysis has been applied to business organizations but has not been done historically. The methodological innovation at the heart of this study is to combine the tools of sequence analysis and network analysis to yield a sequence analysis of changing network positions.

Knowledge Networks: Inter-organizational

Industrial Districts as Distributed Knowledge Networks

Lucio Biggiero & Caterina Muzzi

Industrial districts are regional multi-level hyper-networks, whose actors interact through economic, social, cognitive and symbolic relations, and create dense and recursive patterns of communication. Three levels of networks are identified, depending on the connections between individuals in a single organization, organizations in an inter-organizational network, and the latter in a district. Capacity of knowledge creation/transfer, which is one of the main factors of district competitiveness, rely upon a net of coevolving knowledge networks, inducing the view of industrial districts as knowledge hyper-networks. Main mechanisms for knowledge transfer and learning processes at inter-organizational and hyper-network levels include: interrelationships between suppliers, customers; formal and informal collaborative agreements; inter-firm mobility of workers inside the district area; and the spin-off of new firms from existing firms, universities and public sector research laboratories.

Beyond traditional means through which codified or migratory knowledge (books, designs, blueprints, computer programs) flows among actors, a crucial role is played by tacit (or embedded) knowledge transfer mechanisms, especially at intra and inter-organizational levels. Tacit knowledge is diffused through processes of imitation, emulation and reverse engineering, and it is situated in the " district memory": success stories, past solutions of technical problems, and "natural" artisan ability. Thus, knowledge creation/transfer appears as an emergent property, strongly path-dependent and embedded into interacting processes between people, organizations and inter-organizational networks, instead of being a property of single different agents. The main goal of the paper is a first attempt to modeling industrial districts as parallel distributed processors of knowledge, checking different approaches, like cellular automata, boolean networks, or other agent based models. At each of the three district level, a set of actors is identified and a set of mechanisms of interaction is defined. The second goal is to distinguish two patterns of interaction depending on the case of transferring codified or tacit knowledge.

Knowledge Creation and Transfer at Multiple Levels: Structuring Knowledge Networks for "Small-World"

Effects Melissa Schilling & Corey Phelps

The capacity to create, acquire, store, and transfer knowledge is the wellspring from which progress arises. Accordingly, scholars have dedicated great effort to exploring how knowledge is created and transferred, and how these processes may be facilitated at the individual, group, and firm levels. Our research shows that a strikingly similar pattern can be identified among the findings of diverse research streams on knowledge creation and transfer, and that this pattern is consistent with relatively recent results emerging from work in graph theory on "small-world" networks.

Though social scientists had demonstrated small-world properties in social networks (Milgram, 1967), the mathematical properties underlying small-world networks were only recently discovered (Watts & Strogatz, 1998). Small-world networks are those in which clusters of densely connected nodes are loosely connected within a much larger network such that the overall network has both a high clustering coefficient and a short characteristic path length. In the short time since their discovery, the

properties of small-world networks have rapidly found application in biology, sociology, physics, and other disciplines.

We propose that knowledge networks at diverse levels of analysis demonstrate small-world network effects. We further propose that knowledge networks can be deliberately structured to exploit small-world properties and thereby enhance the rate of knowledge creation and transfer. We review relevant research streams on knowledge creation and transfer at the individual, group, and firm levels. Each of the streams we focus on has incorporated (explicitly or implicitly) both 1) recombinant search and 2) network principles. By Focussing on these elements in each of the literatures, we demonstrate a consistent pattern among the different levels of analysis. When this pattern is then examined within a small-worlds framework, it becomes clear why this consistency should emerge: each stream has independently revealed the value of structuring knowledge networks to create small-world effects.

Rationality, Structure, and Co-Orientation: Comparing Advice Networks in Different Intra- and Inter-Organizational Contexts

Emmanuel Lazega, Rafael Stofer & Olivier Wattebled

After establishing the importance of Blau-ties (i.e. duplex mutual co-worker tie combined with a unidirectional advice tie) for individual and collective performance in organizations, we look for « elementary » relational substructures needed to help members of various social contexts in making informed work-related decisions. For that purpose, we use comparisons across several advice networks collected in intra- and inter-organizational contexts where actors are involved in knowledge intensive work. This approach is then used to think about necessary relational conditions for coorientation in collective action.

Advances in Communities of Practice and Social Capital Through a Social Network Approach: An In-Depth Study of the Swedish Biotech Industry

Andrew Schenkel & Robin Teigland

Communities of practice (CPs) continue to draw considerable interest for their critical role in the creation, dissemination, and embedding of organizational knowledge. However, CP research is still in its infancy and two main areas need to be further investigated: 1) the mechanisms with which communities of practice operate and 2) the relationship between CPs and performance. To better understand CP mechanisms, some researchers are turning to social capital. Social capital is argued to consist of three dimensions: structural, relational, and cognitive. While relational and cognitive capital have been somewhat easier to research, the structural dimension of communities of practice has presented some problems due to the informal, almost ethereal, emergent structures of CPs. In addition, due to this "soft" nature of communities, the relationship between communities of practice and performance, be it individual or organizational, has also presented difficulties to researchers.

However, decades of work within social network analysis have led to a vast array of analytical tools to help understand organizational structures and thus show promise as a means to fill the above research gaps. First, social networks are argued to be the foundation of social capital, and preliminary studies show that network concepts can be synthesized with community of practice concepts to develop CP-specific network concepts. Second, considerable research on how network embeddedness shapes individual and organizational outcomes can be applied to provide some insight on the relationship between CPs and performance.

Thus, in this paper we develop the background for a research study focusing on the above two areas. The intent is to build on the social network research conducted already within the US biotech industry. In particular, we plan to focus on Sweden's emerging stem cell biotech industry and, in this manner, to better understand the development and role of CPs over time.

Evolution of Network Structures and Structures of Network Evolution

Event Analysis: A Method which Characterizes an Event through Community Pattern Changes

Naomi Yamashita & Toru Ishida

Social Network Analysis has been studied extensively in the past. However, there are few analytical methods which deal with the dynamic process of a social network. In this paper, we focus on "events" (e.g., marriage, divorce, demotion, etc.) which cause changes in social network communities. As we may see, there are many possible ways of social network transitions which may be caused by a single event, say marriage for example. However, there must be something in common among these network changes. Then, the following questions arise. What is the essence of the social network transition? Are there any relations or specific rules between events and the changes in community network patterns? In order to extract the essence, how can we express events through community pattern changes, and how can we extract the essence of community pattern changes? Our research goal of this paper is to propose an analytical method which provides answers to these questions. Our method expresses the notion of an event in simple mathematics.

In this paper, we first express a network as a vector, and an event as a linear transformation. More precisely, we denote the network before an event by vector x, the network after an event by vector y. Next, we denote an event by f and assume that f transforms x into y, that is, $f(x) = y$. We then estimate the linear function f from sample data sets of the event. Using our method, we may identify several events named differently as an essentially same event (e.g., Network transitions based on "marriage" and "consolidation of companies" are basically the same!). We believe that our method deepens and broadens the understanding of community transition.

Medical Innovation Revisited II: Two-Stage Partial Observability Models of Innovation Adoption

Christophe Van den Bulte & Gary L. Lilien

Many theories on the adoption and diffusion of innovations posit that adoption is the outcome of a decision process. A two-stage conception, awareness followed by evaluation and adoption, seems particularly useful. Several empirical studies indicate that the effect of mass media and change agents is relatively concentrated in creating awareness, while the effect of personal influence from earlier adopters (i.e., social contagion) is relatively concentrated in bringing about a positive evaluation and hence adoption. A frustrating problem, however, is that most data record only the final outcome of the process, i.e. the time of adoption. We bridge this gap in richness between theory and data by developing new models, which we call partial observability models of innovation adoption. An application to

the classic Medical Innovation data illustrates that these finer-grained models can not only provide better descriptive fit but, more importantly, can also detect weak social contagion patterns that traditional event history models, such as those used by Van den Bulte and Lilien (AJS 2001), cannot detect in the presence of strong mass media effects.

The Social Networks in a Local Innovation System of Brazilian Northeast

Julio Francisco Dantas de Rezende

The Local Innovation System of Technology Center of Natural Gas-CTGÁS in Rio Grande do Norte (a Brazilian northeastern state) has been studied verifying its interaction with the university and Government. The aim of this research is to check out the social network existent in the Local Innovation System between CTGÁS and cooperators (Universidade Federal do Rio Grande do Norte-UFRN and Government). This study is based on Sabato's and Botana's (1968) theory, which focuses three sorts of relation: intra-relations, inter-relations and extra-relations. In order to do the analysis it was used the Triple Helix Model of Leydesdorf and Etzkowitz (1997) and Social Network method such as adopted by Lazega & Pattison (1999). The methodology adopted here has a qualitative, explorative and descriptive nature. The data choice was intentional and it was collected by questionnaires, interviews and non-official information. Aspects related to the innovation management such as motivation for interaction were evaluated, dealing, hiring and the prospecting of new researches, the process of communication in the social network and the transfer of technology between and CTGÁS and UFRN. The main results pointed out the trust given by CTGÁS to the researchers from UFRN, as well as the facilities of the hiring the same and emphasizes satisfaction by the conclusion of the research without the need of extra time or resources improvements. Yet the interest of interacting with the departments of UFRN was noticed as long as the current projects are concluded. We can notice the importance of integration amongst CTGÁS helixes, UFRN and Government, as well as the auto-responsibility of each helix in search of solutions, avoiding thus, that a singular sector gets all obligations in this social network.

Networks, Drug Abuse, and HIV

HIV Microevolution in Sexual/IVDU Networks

Steven Goodreau

Social network analysis has proven remarkably successful in uncovering previously overlooked patterns of sexual behaviour that have major effects on the trajectory of an HIV or STD epidemic. Here I extend this line of work into the question of HIV microevolution, the pattern of neutral genetic diversity that arises among HIV seropositive individuals in a single infection network. Most population genetic methods for analysing this variation make the untenable assumption that the partnership networks generating it were random. I present a general framework for simulating viral spread and evolution in populations with structured mixing. This framework involves actor-based microsimulation, a necessary component when tracking viral evolution that is so rapid as to create unique genetic sequences among every seropositive individual. It is also dynamic in the sense that individual partnerships form and dissolve over time. The framework is applied to five mixing models: purely random, assortative within two clusters, assortative within eight clusters, divided into core and periphery, and divided into sex workers, clients, and clients' wives. These model populations yield significant differences in prevalence and in summary measures of genetic diversity. Possible interpretations and applications will be discussed.

Who is King of the Hill? A Method for Choosing PHAs Among Street Drug Users

Scott Clair, Peg Weeks & Stephen P. Borgatti

This presentation will examine in detail a method to choose potential individuals for an intervention based on network information. Specifically the data is based on a sample of approximately 300 drug users in CT and the goal is to identify specific individuals to take part as Peer Health Advocates in a new peer based intervention project. The assumptions of the method will be spelled out as well as the limitations inherent in those assumptions.

Size, Composition, and Risk Behaviours in Drug User Networks: A Multi-site Comparison

David C. Bell, Samuel R. Friedman,
Carl Larkin, Richard B. Rothenberg,
Victoria Mosier, John S. Atkinson, & Janeene A. Patek

HIV transmission is socially organized through cooperative activities like sex and injection drug use. A social network view of HIV transmission emphasizes the organization of the pathways by which transmission can occur. Ego network data are presented from five NIDA-funded studies that have collected network-based samples. The Colorado Springs Study was conducted in 1988-1991; the Stop AIDS For Everyone study was conducted in Baltimore in 1991-1992; the Social Factors and HIV Risk study was conducted in the Bushwick neighborhood in New York City in 1991-1993; the Urban Networks Study in Atlanta was conducted in 1995-1999; and the Risk Networks Study was conducted in Houston in 1997-1999. The five sites varied considerably in HIV seroprevalence at the time the data were collected. Data reported on ego networks include total network size, network composition, number of drug injection partners, frequency of injection risk Behaviours, number of sex partners, and frequency of sex risk Behaviours. In some studies, samples of nonusers were also collected in order to distinguish the effects of drug use and social environment. Cross-site comparisons of drug user networks, and in some cases nonuser networks, will help to reveal some of the variation in network size and structure that occurs in the drug user community. These data provide information about the range in some key network patterns that may affect optimal strategies and tactics in HIV intervention programs.

Science & Technology: Innovation & Diffusion

The Decision-making Process in the Field of R&D

Wolfgang Neurath

Long before a diffusion process of an innovation occur far-reaching decisions about Research and Development are made. Obviously, there is a great amount of uncertainty in the whole process of the generation of innovation, because the more basic research from an industrial perspective, the greater the return of investment, the greater are also possibly the market chances for the innovation. Hence, the interest of industry is to establish a research system based on public funding and to exert influence

on the decision-making process there. It's in the interest of the public to support research with a higher innovative impact. To minimize the uncertainty public and private organisations have developed a great amount of specific tools to evaluate the economic impacts of (basic)research. The European Commission and the member states have also established a more or less formal decision-making. Innovation networks have often become invisible, but they are considered decisive and significant. The paper will address these problems on the basis of the theoretical foundation of an empirical study of the role and influence of private innovation networks in the decision-making process. It describes the procedures embedded in the their social structure. The role of social capital is also to be explored. The sampling procedure consists of a two-step process. In the first phase, thirty decision-makers in Austria will be interviewed, while background interviews and specific date are evaluated. I will also present the design at the conference.

Interaction Between Science and Technology in Biotechnology

Robert Dalpe & Louise Bouchard

This paper deals with the new research dynamics in biotechnology generated by industry's direct relations with university's or public laboratory's researchers. Due to potential commercial applications of a large segment of research in public organizations, researchers established close interactions with industry and new practices are set. University based biotechnology research is therefore more largely financed by private contracts, and patenting is more frequent than in other disciplines. Industry's involvement however imposes new constraints to scientific research, for instance in the area of information diffusion since industrial commercialization requires that firms appropriate research results and secure property rights prior to public diffusion. Several studies in sociology of science sustain that a new research dynamic is progressively replacing the "Republic of Science." Sociology of networks put emphasis on the social dimensions of these interactions and more specifically on trust between actors. Face-to-face contacts and long-term relationships solidify networks and deter opportunistic behaviours. Our objective is to determine how researchers act and respond to their new environment and what types of constraints are imposed.

We present results from a case study dealing with the discovery of two genes associated with breast and ovarian cancers, BRCA1 and BRCA2. The analysis is based on in-depth interviews of ten researchers exemplifying the different profiles in research dynamics. The new research dynamic for seen by sociology of science and biotechnology studies is only in its infancy and national differences are still important. Some Europeans teams maintain a traditional scientific organization, hiring almost solely graduate students on the basis of exclusively public financing, although two North-American respondents have adopted different research dynamics. Firms and public organizations engaged in frequent conflicts concerning patenting of both genes and their subsequent industrial applications Our data suggest that scientific collaboration is more difficult when intellectual property is an issue.

Innovation Networks in the Boston Area Biotechnology Community

Jason Owen-Smith & Walter W. Powell

High-technology firms in the United States and Europe tend to cluster in specific geographic regions. Co-location with other firms and public research organizations is beneficial in knowledge industries as proximity promotes information spillovers. Network position also affects innovation in knowledge-based firms. Heterogeneous networks of strategic alliances increase firm performance by channelling information spillovers and increasing rates of learning. Examinations of firm-level innovation often emphasize either geographic proximity or network position to account for the outputs of firms. We argue, instead, that geographically proximate firms are simultaneously embedded in local and trans-local networks of strategic alliances. Position in these two types of networks differently effects a firm's ability to innovate.

We examine the consequences of geographic location and network position for patenting by biotechnology firms in the Boston metropolitan areas. Using ten years of data on firm level strategic alliances and patenting we construct measures of network position both within and outside the Boston region to test the effects of geographically bounded social networks on innovation. We find that the cohesiveness of the Boston biotechnology community greatly increases with the diversity of organizational participants, the addition of geographically distant partners, and the maturity of the industry. Drawing on fixed effects negative binomial models of a pooled cross-section of network and patenting data, we demonstrate that within the geographic region, any connection to the largest social network component positively effects firm patenting in later years. In contrast, when strategic alliance networks include geographically distant partners, greater centrality in the network increases later firm patenting. The innovation benefits of social network position in biotechnology, then, vary with the geographic proximity and institutional diversity of partners.

Personal Community Networks: Sampling Personal Networks

Measuring Personal Networks with Daily Contacts: Comparison of a Single Survey Item and a Diary Log

Yang-Chih Fu

Measurements of personal networks include two major variants. One determines the structure that conditions one's actions, the other detects the scope and nature of one's social contacts involved in these actions. This paper examines two extreme measurements of social contacts that are relatively novel to the literature. The first measurement is a single survey item that asks "About how many persons do you have contact with in a typical day?" The answers include six ordinal categories ranging from "0-4 persons" to "over 100 persons". The second measurement is a diary log that records detailed information about every single contact in one's daily life. The log includes three major parts: (1) characteristics of each specific contact that occurs in daily life; (2) demographic characteristics and socioeconomic status of each person contacted; and (3) characteristics of the relationship between the contact person (alter) and the ego. While the first measurement is extremely simple and straightforward, the second is very tedious to record and thus difficult to collect. Both can be valuable in revealing basic and critical dimensions of personal networks, and effective in explaining Behaviours and attitudes. On the one hand, the single survey item serves as a basic index of personal networks and helps understand a wide range of related topics as well as network characteristics. The diary log, on the other hand, uncovers key ingredients of personal networks and provides great potentials to

further understand the individual through in-depth information about daily contacts. In this paper I plan to analyse and compare the two measurements with several data sets collected in large-scale surveys in Taiwan and China during the past three years, and two complete sets of diary log recorded by the informants over three months.

Are Respondents More Likely to List Alters with Certain Characteristics? Implications for Name Generator Data

Alexandra Marin

Analyses of ego-centric networks make the implicit assumption that the list of alters elicited by name generators is a complete list or representative sample of all the alters who share the elicited relationship with R. Based on the literature on free recall tasks and the organization of people in memory I hypothesize that respondents presented with a name generator are more likely to name alters with whom they share stronger ties, alters who are more connected within the network, and alters with whom they interact in more settings. To test these hypotheses I conducted a survey that began with the GSS name generator and then prompted them to remember other relevant alters whom they had not yet listed. By comparing the alters elicited before and after prompts I find support for the first two hypotheses. I then go on to compare network level measures (size, mean closeness, density, mean length of relationship) calculated with the alters elicited by the name generator to the same measures calculated with data from all alters. Results indicate that these measures are not well correlated. The correlation is particularly low for network size. Furthermore, the degree of underestimation of network size is related to the networks mean closeness, density, and mean duration of relationships such that higher values on these variables result in more accurate estimation of network size. These results suggest that measures of ego-centric network properties using data collected using a single name generator may have high levels of measurement error, possibly resulting in misestimation of how these network properties relate to other variables.

Collecting Ego-Centered Network Data Via the Web

Valentina Hlebec, Katja Lozar Manfreda, Samo Dekleva, Vasja Vehovar & Zenal Batagelj

Face to face survey is a typical data source for ego-centered social networks owing to their complex data structure. Usually an interviewer is required to handle the list of alters (thus reducing typing errors and misunderstandings) and the respondent is given help when answering questions about each alter. Web data collection can substantially reduce the costs and time required for data collection of ego-centered data, as compared to face-to-face or telephone interviews. Such data collection is especially suitable for special populations familiar with Internet tools. However, special attention to questionnaire design is needed if the respondent will complete the Web questionnaire by him or her self-- compiling a list of alters and giving information about them. One trial in the collection of ego-centered networks via the Web was done in the annual RIS (Research on Internet in Slovenia) Web survey conducted by the Faculty of Social Sciences, University of Ljubljana. Respondents were randomly split into four groups. Each group received a name generator for one type of social support: material, informational, emotional support or social companionship. Each respondent also received a set of questions regarding alters for each alter they named in the network generator. Data collection was performed in August and September 2001. About 250 respondents answered the Web questionnaire for each type of social support (1000 respondents altogether). Dropouts from the questionnaire are studied with respect to the number of listed alters and characteristics of respondents. Preliminary analysis shows that the Web can be used as a data collection method for ego-centered social networks. However, special attention is required when designing the graphic characteristics of name generators as well as with the wording of instructions. In particular, the number of alters should be limited in some substantial way since respondents who name many alters tend to quit the questionnaire before answering additional questions regarding these alters.

Politics Through Networks

Consulting with SNA in the Context of Political Organizations: Models and Experiences

Harald Katzmair

The paper will focus on three main topics: First the impact of New-Product Diffusion Models for planning political strategies. Second, the methodological tools for identifying central social groups that can be targeted most efficiently either by word-of-mouth or by mass media communication. Third, the meaning of identifying the right bridgers to speed up the process of creating "Buzz". The main goal of the paper is to show that the success of consulting a political NPO depends on the ability to find the right political change agents and opinion brokers that are able to convey the different cultural codes separating one network cluster from another. Without the bridging efforts of such "multilingual" translators you cannot initiate a process of effective diffusion of opinions both within the political organization itself and inside the different networks of public opinion. But how are those political brokers to be identified in- and outside of our clients organizations?

Influence and Connections: Analysing the Structure of Health Policy Networks

Jenny M Lewis

Policy making in health is highly structured in terms of networks of influence. Yet we have little information on how networks effect health policy making. This study aims to address this gap by describing and analysing network structures of influence in the state of Victoria. A snowballing method was used to generate a list of people who were regarded as influential in the health policy process. 62 of the 115 people contacted (54%) completed forms nominating who they regarded as having influence and indicating whether they had ongoing contact with these nominated influentials. Blockmodelling of these data generated eight blocks: a core block of very influential people; one associated with acute care; one of public health academics and associated researchers; one associated with a particular university; one of people interested in particular diseases or communities, one with a consumer and legal focus, one of people who were peripheral but connected; and one of people who listed influentials only in their defined area. On the basis of the total number of nominations received and coverage of seven of the eight blocks (with the last block excluded), 22 people were selected for interviews, and were asked about the main current issues they are working on and who they are working with. The results from this were then compared with a similar study of influence carried out in 1991-3. Substantial changes in the structures of influence in health policy and the main issues have occurred over the last decade.

Policy Formulation in an Internationalized Environment: a Network Analysis of Switzerland's Immigration Policy Towards the European Union

Alex Fischer, Pascal Sciarini & Sarah Nicolet

Our paper applies the tools of network analysis to the study of a public policy in Switzerland, more specifically to the study of the policy network responsible for the elaboration of the Swiss immigration policy towards the European Union (EU). This policy was discussed and settled in the context of bilateral talks between Switzerland and the EU on the free movement of persons. The Swiss policy network under consideration is divided into two distinct networks: one responsible for the elaboration of the Swiss position during the negotiation with the EU, the one responsible for the elaboration of the "flanking measures" on the same topic, measures which were aimed at circumventing internal dissent during the ratification process. Our data stem from 50 interviews with the Swiss political elite of the policy domain under consideration carried out in the summer and fall of 2001. We use the tools of network analysis (centrality, cliques, structural equivalence, multiplexity, biased net theory) to describe and compare the power configuration in the two domestic networks. In addition, we confront our results to a qualitative analysis of the bargaining process. The mix of quantitative and qualitative analyses help us to highlight the interplay between power configuration, actors' strategies and the mediating role of political institutions.

Generalizations of p*

Choices of Theatre Events: p Models for Affiliation Networks with Attributes*

Filip Agneessens, Henk Roose & Hans Waege

Since p* models were first proposed for the analysis of local neighborhood structures in 1-mode networks (Wasserman & Pattison, 1996) work has advanced on two distinct fronts. On the one hand, p* models have been extended to 2-mode networks. On the other hand, p* models have been developed to include attributes of actors. In this paper we combine both developments and propose a p* model for 2-mode networks that incorporates attributes of the events and attributes of the actors.

By means of this model, we aim to describe the choices of specific theatre performances made by the theatre audience in the city of Ghent (Belgium). Using actor 2-stars and event 2-stars with attributes, we will simultaneously address the following research questions:

- Are the patterns of choice related to the attributes of the performances (the institution)?
- Do age, educational level and esthetic expectations of the actors explain these patterns of choice?

Social Networks and Small Worlds

Garry Robins, Philippa Pattison & Jodie Woolcock

Our understanding of the small world phenomenon has been considerably advanced by the work of Watts and Strogatz (1998). Their simulation algorithm for examining small worlds, however, requires an initial global structure for a graph and a specific stopping rule, neither of which have a natural interpretation in the way that observed social networks might be generated through local processes. We present results from a simulation study of small world graphs, using exponential random graph (p*) models. We simulate exponential random graph distributions using the Metropolis-Hastings algorithm, and thereby avoid the need for a connected substrate as a starting point, for graphs to remain connected during the simulation, and for an arbitrary stopping rule. Further, the parameters of the distribution have a natural interpretation in terms of local processes that are hypothesized to generate the graphs.

We present criteria for a small world distribution of graphs, by relating a simulated distribution to appropriate Bernoulli or U | L distributions of graphs. With different choices of parameter values, we are able to generate a variety of "worlds": small worlds, highly centralized graphs, long path worlds, and Watts and Strogatz's "caveman" worlds. In our small world distributions, a trade-off between clustering and "short-cuts" appears to result in multiple intersecting large cycles that permit the small world properties to emerge. Our results confirm that small worlds can emerge when some randomness is combined with a tendency towards transitivity, but they also highlight the importance of particular features of the degree distribution in characterising small worlds.

p in MultiNet*

Andrew Seary & William Richards

We describe the implementation of p* in MultiNet, and discuss various aspects of p* fitting with special types of data: large; symmetric; bipartite; multiple network. Since the program can handle up to 10,000 nodes and 256 parameters, managing the displays and reports can be quite complex. We demonstrate the use of the program with moderately large datasets.

Degeneracy and Inference for Social Network Models

Mark S. Handcock

We describe some advances in the modeling of random graphs that have an impact on the representation of sexual and drug use networks. We also investigate issues related to the specification and estimation of random graph models. The main focus is cross-sectional data.

To date, the use of random graph models for networks has been limited by three interrelated factors: the complexity of realistic models, lack of use of simulation studies, and a poor understanding of the properties of inferential methods. In this paper we discuss these factors and related issues of the degeneracy of commonly promoted models. We present Markov Chain Monte Carlo (MCMC) algorithms for general random graph models. We also review the role of these MCMC algorithms for simulation, addressing model degeneracy, implementing Bayesian formulations and likelihood-based inference. These ideas are applied to a sexual relations network from Colorado Springs with the objective of understanding the social determinants of HIV spread.

Communication Networks, Performance, and Decision Making

Does Network Position Influence How People Make Decisions? A Test of Friedkin's Social Influence Network Theory

Stacy Wolski

The organized structure of every individual self within the human social process of experience and behaviour reflects, and is constituted by, the organized relational pattern of that process as a whole... (Mead, 1934).

It is by no means unique to claim that individual attitudes and interpersonal connections work together to influence the formation of subsequent attitudes and behavioural intentions. The idea that decisions are a product of what an individual thinks as well as what others think is a long recognized phenomenon within the social science literature (e.g., Ajzen & Fishbein, 1980; Lewin, 1936; Mead, 1934; Trafimow & Davis, 1993). Noah Friedkin offers a conceptually elegant theory of how attitudes and interpersonal influences are integrated to form behavioural intentions at both the individual and the structural level, effectively bridging the gap between micro and macro levels of analysis (1998). In hopes of providing empirical support for the purpose of theoretical development, a study is presented that tests a foundational assumption embedded in this theory. This paper reports operationalizations of the variables necessary to provide a good test of the theory, describes the analysis plan, and presents pilot analysis results. Necessary variables for this test include individual attitudes, interpersonal influences, and behavioural intentions, operationalizations of which are adapted from the related theoretical work of Ajzen and Fishbein (1980) and Bandura (1986). Data analysis is twofold: calculations of in-degree centrality are used to determine network position and a random-effects multilevel model analysis is conducted to address the hypothesis that inquires about how the weights associated with attitude and interpersonal influence vary across levels of centrality. Lastly, although the pilot dataset collected from three academic departments sampled from a large southwestern university is too small to be conclusive, it offers useful preliminary information about the data required to conduct this empirical test.

Structural Properties of Work Groups and Their Consequences for Performance

Jonathon N. Cummings

Social network research has traditionally favoured either the ego-network (e.g., employee) or the complete network (e.g., organization) as the primary unit of analysis. This paper focuses on the work group, which includes structural properties of both its individual members and the collection as a whole. In a study of 182 work groups in a global organization, we found that structural holes of leaders within the groups as well as core-periphery and hierarchical group structures were negatively associated with performance. We show that these effects hold even when controlling for mean levels of group communication, and discuss implications for the future of network analysis in work groups and informal organizations.

The Effects of the Social Network upon Performance in Three Cohorts of an Undergraduate Degree

Elaine Scott

Social networks have been seen to have an effect upon the performance of both individuals and teams within organisations. In an educational context performance is measured by a students' grades, the effects of social networks has been noted upon the performance of students at Masters degree level. This study aims to explore the effects of such social networks on the performance of individuals and groups in three cohorts of undergraduate students.

Information on the social networks of the three cohorts was gathered with the use of a roster choice questionnaire. The questionnaire listed each member of the cohort and required the individual to identify with whom he / she is friends and with whom he / she communicates regarding school related issues. With the use of UCINET 5 this data was used to investigate the social networks of the three cohorts, the placing of individuals within these networks, and interactions within and amongst self - assigned project groups. Further information was gathered regarding the self - assigned groups in the form of a peer group assessment. The students were asked to rate the members of their group on a Likert scale in terms of effort within the group, intellectual contribution, and overall co-operation with the other members of their work group. The relationship between the network and peer group assessment data and individual and group grades was then investigated. Preliminary results indicate that there is significant correlation between students' grades and the degree to which they are sought out for communication in all three cohorts. In the second and third year cohorts there was also significant correlation between grades and the 'in degree' of friendship. Only in the third year cohort was there evidence of significant correlation between students' grades and their 'out degree' of communication.

Understanding Reform Capacity Through the Application of a Social Network Analysis Model

Maryann Durland

This paper is about the development and use of the CCMSE - the Centrality Cohesiveness Model of School Effectiveness -as a tool for understanding the capacity of an organization, such as school faculties, to engage in reform processes and activities. The premise for the model is that the level of school reform success is related to the structural capacity of the faculty to engage in reform activities and processes. Two key indicators of effective schools have consistently been leadership - primarily of the principal, and the cohesiveness of the faculty. This model uses network analysis indicators and measures to develop a profile of a faculty. This session will track the development of the model, and will outline the measures used and the process for creating the profiles. Profiles are useful for facilitating faculty development through the process of creating the organizational structures for implementing reform initiatives and for understanding how the organizational structure impacts reform initiatives. The pro-files, with the visualisations of the networks, help faculties understand the dynamics of change within organizations and the complexity of change and reform for organizations. Though this paper focuses on school faculties, applications of the model to other types of organizations is also appropriate and will be mentioned.

Networks and Corporate Performance

Structural Embeddedness in the Making of Financial Capital

Andrew V. Shipilov

This paper investigates the conditions under which the relationships between the structure of producer's direct ties to its partners and performance are affected by producer's network centrality as well as by the fluctuations in market growth. I suggest that there is no single optimal structure for producer's local networks, but rather there are multiple configurations that

should be constructed in response to specific environmental and network dynamics. To corroborate my ideas, I use data on all syndicates formed by Canadian investment banks to underwrite public offerings between 1952 and 1990. I find that market participants with low centrality should structure their local networks either around intense embedded ties with few partners or around weak arms-length ties to multiple partners, whereas the reliance on the portfolio of embedded and arms-length ties will decrease producers' performance, since the costs of maintaining both types of relationships overweigh its benefits. The situation reverses, when one looks at the local networks formed by the ego's partners. For a focal player it is actually advantageous when its alliance partners use the mix of embedded and arms-length ties in their networks, so that the focal firm can reap the benefits of its partners' diversification. Furthermore, as producers' centrality grows, they will perform well by relying primarily on embedded ties, whereas forming local networks structured around arms-length ties will lead to the reduction in the producers' performance. Finally, as the demand for the producers' output increases, it becomes more beneficial for the company to be connected to the group of alliance partners, which are linked primarily through the arms-length ties.

Financial Technology Firms Interorganizational Networks

Francois Collet

This paper examines the structure, evolution and impact on performance of alliances networks for financial technology firms. Longitudinal data on these firms and alliances has been collected in specialised directories, alliances and merger databases and specialised publications. The structure and evolution of the network is analysed. Preliminary results on the influence of prior alliances on the formation of new alliances are presented. The distribution of financial, commercial, technical and social capital is examined. The relevance of the structural hole vs. cohesion argument for different type of alliances is discussed and some hypotheses derived.

Improving Technology Adoption Through Inter-Organizational Communication Networks

Cataldo D. Ruta & Chiara Frigerio

In the recent years, many researchers have studied how organizational structures constrain or facilitate the adoption / implementation of information technologies. Technology-related issues in the implementation of a groupware include the identification of the new system's requirements involving end-users, to match if and how much end-users requirements are covered by packages functionalities and to estimate the efforts to customize such systems to the organization's needs. We argue that to facilitate this process, potential adopters of a groupware should be part of an inter-organizational network. This relational structure enables people s access to resources, such as potential communication partners on the new system, or expertise as to how to use the system. To be part of a network means to introduce support services and activate mechanisms to collect end-users feedbacks in order to solve problems and to develop a new future release. When it happens, end-users are involved in the implementation process and inter-organizational communication networks can increase the value of continuous training for effective technology use and for Focussing training on use of the technology in practice rather than simply on the mechanisms of its operation. Training and development networks are intended to create or enhance knowledge, skills, and abilities of individuals to help them to perform at higher levels. We studied how eight banks implemented a groupware to re-engineer the same processes. Four of them constituted a network to customize the system and to facilitate the adoption process, in terms of how to use the system and how to apply its functionality to their working activities. Banks, and then end-users, that work isolated found more difficulties in learning how to use the system and to improve its functionalities. Results suggest that the network is a way to increase the awareness and the involvement of end-users in the implementation process and then the effectiveness of the related activities. The research tries to integrate the network approach with technology adoption for the purpose of studying inter-organizational communication network as facilitator of the implementation process.

The Impact of Organizational and Alliance-based Complexity on the Development of Alliance Capacity

Ha Hoang

Viewing alliances as vehicles for learning, this study examines how the development of, and limits to, alliance capacity affects the ability of firms to engage in subsequent alliances. Alliance capacity is defined as an ability to integrate and leverage knowledge from multiple alliances. As barriers to this process, organizational and alliance-based complexity was posited to limit the development of alliance capacity. Analysis of 229 biotechnology- pharmaceutical firm dyads followed over a 15-year time period shows that alliance capacity affects alliance formation. Complexity hinders the development of alliance capacity but biotechnology firms show greater vulnerability to alliance complexity while pharmaceutical firms are affected by their greater organizational complexity.

Corporate Consulting with Social Network Analysis

Organizational Network Analysis @ IBM

Gerry Falkowski

Gerry Falkowski's will provide an overview of how consultants in the IBM Consulting Group uses an Organizational Network Assessment, enabled by the InFlow software, to determine if an organization is sharing and reusing information and knowledge optimally. Discussion will focus on techniques used to pinpoints gaps in knowledge sharing and reuse, and how to develop action to achieve better knowledge sharing. Specifically....

- How to validate what is already suspect and provide clarity on how to further improve how a team works together to support each other and their customer.
- How to determining if the appropriate people to people communications are linked, identifying gaps, and providing actions to continue building relationships built on trust and mutual respect.
- How to identifying your key knowledge assets, both social capital (people) and intellectual capital (data bases, team rooms, websites) and developing actions to further facilitate appropriate knowledge reuse, sharing and innovative Behaviours.

SNA @ IBM's Institute for Knowledge Management

Robert Cross

Rob Cross will discuss practical applications of social network analysis based on his work over the past several years directing research on social networks at the Institute for Knowledge Management. He will present a series of cases and models (forth-

coming in Sloan Management Review, California Management Review and Organizational Dynamics) regarding the application of social network analysis to assess and support knowledge intensive work. While consulting can naturally follow from these cases and models, his presentation will also focus on practical benefits that researchers can offer organizations in study designs that might be primarily focussed on scholarly interests. Specific topics will include:

- Promoting cross-boundary collaboration at critical network junctures (e.g., functional, organizational, hierarchical or physical boundaries).
- Assessing and integrating different kinds of expertise within organizations.
- Promoting the latent ability of an entire network to share and create knowledge.
- Integrating different networks in large scale change initiatives (e.g., post merger management).

Evolution of SNA in Business -- One Historical Perspective

Valdis Krebs

Valdis Krebs will discuss his experience in management consulting and social network analysis. He will take a historical approach -- linking the consulting, social network analysis and the growth of his software, InFlow. We will see how the software and SNA methodology changed based on clients' wants and needs. He will share how SNA was adopted to various business trends such as TQM, Workforce Diversity, Business Process Design and Knowledge Management. Along the way many lessons learned and humorous stories about SNA in business.

Valdis will discuss various SNA projects in the following business areas:

- knowledge management
- post-merger integration
- workforce diversity
- employee retention/turnover
- organization design
- project team improvement
- computer network design
- strategic alliance planning

Roundtable on IRB Refusals to Allow Network Research

Alden Klovdahl

Following some 'adverse events' in social-geneticand other research many Institutional Review Board have been taking a much more conservative approach to research approvals. In some cases, persons named in a social network questionnaire/interview as contacts or associates are defined – according to the common federal rule – as human subjects. As such, informed consent can be required by an IRB if identifying information about these contacts/associates is to be obtained. Such an approach makes social network research difficult if not impossible. An alternative allowed by present rules is for a 'waiver of consent' to be approved by the IRB. Some IRB's have been unwilling to do this for network research. This is an area in flux and a number of groups are moving ahead with proposed changes to the rules. The purpose of the roundtable is to begin a discussion of the relevant issues and to consider whether - and if so how - social network researchers should be making a greater effort to contribute to policy making in this area. ... if it is not too late. Contributions are welcomed from any with knowledge of relevant IRB experiences (favourable or unfavourable) … unlike social network research, identifying information is not required.

Health Behaviours and Networks

Friendship Patterns of Adolescents by Race/Ethnicity

Beth R. Hoffman & Thomas W. Valente

This study uses social network analysis to examine the friendship patterns of middle school students. As part of a larger survey, students at four schools in Southern California indicated their ethnicity and the names of three friends in their grade. It is hypothesized that students will be more likely to have friends of their ethnic group than friends of other ethnic groups. Results show that students were more likely to nominate friends of their ethnicity than they were to nominate friends of different ethnicities. As compared to mixed ethnicity students, Asian students were significantly less likely to have White friends, and over 5 times as likely to have Asian friends. Latino students were more likely than mixed students to have Latino friends, and "other" students were more likely than mixed ethnicity students to have "other" friends. There are differences in friendship patterns by school as well, some of which seem to be related to the ethnic composition of the school sample. Students at a school where 34% of the students were White were more likely to have White friends than at the comparison school, where approximately 9% of the sample was White. However, students at three schools were all less likely to have Asian friends than were students at the comparison school. These findings were not due to variation in school compositions. Since rates of smoking vary by ethnicity, these findings have implications for determining the role of peer influence on adolescent smoking and planning effective prevention programs. As friendship patterns vary by school, patterns of social influence to smoke may vary as well. In the future, program innovators may wish to tailor the intervention to the social climate of the school for maximum efficacy.

Modeling Communication Network Analysis on Fertility Decline

Kaberi Gayen & Robert Raeside

The total fertility rate of Bangladesh declined from 7.0 children per women in 1970s to 3.3 in 1997-99 with a target of 2.6 in 2005. Researchers, policy makers and academicians termed this decline as "success in a challenging environment". This is perceived as surprising because the steep decline in fertility has occurred without a substantial improvement in socio-economic status, health conditions and other factors thought to be essential for fertility decline. The potential for this fertility decline may be traced out in the impact of the rapid diffusion of ideas through communication channels. Communication campaigns in promoting the diffusion of new attitudes about reproduction and thus in speeding reduced fertility is now recognised as a key ideational change agent in demographic research. In family planning, communication campaigns create awareness, increase knowledge, and build public approval of new ideas and practices. Personal family planning decision involves individuals, couples, families, and peer groups. The individual-to-group connections establish path-ways along which such innovative demographic behaviour can diffuse. So, demographic transition in Bangladesh can be better analysed using communication models and understand the degree of influence that communication processes have on changing fertility behaviour. This research examines at the micro level, whether com-

munication network structure influences the decision to choose a family size and at the macro level, whether society's other relational components (such as economic, cultural, social, religious) influence the decisions. Sociometric data will be collected from Bangladesh by structured interviews of samples stratified by locality, economic status and religion. This sociometric data will provide information on the impact of opinion leaders, and other network attributes such as personal network density and structural equivalence in determining fertility behaviour. In this paper the research design and in particular the approach to sampling and the planning of the data collection activity are discussed.

Social Network Mobilization and Influences on Service Utilization Among Drug Users with HIV/ AIDS

Amy R. Knowlton

To examine social support mobilization among injection drug users living with HIV/AIDS, and identify network influences on their access to and use of medical services. Participants were 635 low income African Americans; 47% were HIV seropositive, 45% female, 45% current drug users. A social network methodology elicited structural, functional, and relational network components. Functions assessed were emotional support, physical assistance, and health advice. Relational aspects were number of kin, females, and current drug users in support networks, and having a sex partner. Outcomes were access to the same provider, outpatient care, and emergency room (ER) use without hospitalization. HIV seropositives compared to HIV seronegatives had larger support networks, including more females and kin and sources of physical assistance, and marginally more sources of emotional support, though they were less likely to have a sex partner, after controlling for confounders. Among HIV seropositives, access to care was associated with greater sources of emotional support, physical assistance, and numbers of females in the support network, controlling for AIDS, insurance, drug use, and gender. Having a sex partner was associated with less access to care. Outpatient care was positively associated with size of emotional support network and number of females in the support network. Suboptimal ER use was associated with greater number of active drug users in the support network, controlling for participants' drug use and insurance. Structural network components and kin support were not significant. Results suggest that HIV seropositive low income injection drug users were mobilizing network support, and that supportive others had differential influences on their medical service seeking. Informal caregivers enabled access to care and use of preventive services, while network drug use promoted suboptimal service use, and, contrary to other populations, sex partners impeded access to care. Programs are needed to promote informal care giving and improve access to drug treatment. Findings have implications to economic costs of HIV care.

Roundtable on MultiNet

William Richards and Andrew Seary

MultiNet is a program designed for exploring many types of relationships in complex network data. The program is interactive, fast, supports large networks, and produces both graphical displays and text reports for everything it does. We begin with an overview of the type and format of data the program uses and the data manipulation tools it provides. We demonstrate the univariate and multivariate methods currently available for exploring both attribute (node) and network (link) variables, giving special attention to standard and mixed analytic models the program uses, including discrete and continuous univariate, bivariate, and trivariate methods applied as they are applied to node variables, to link variables, and to mixtures of node and link variables. Throughout the entire session, we use real network data to illustrate procedures, methods, and results.

Once the data format analytic capabilities have been introduced, we move on to the various network tools that are part of MultiNet. These include identification of strong and weak components, pruning trees, identification of various types of partitions, and four types of spectral analysis. Then we demonstrate hybrid methods which allow new node variables to be created from results of analysis. Examples include eigenvectors, partitions, and several centrality measures. We show how the program makes it easy to creating link variables from node attributes and groupings of link variables.

We demonstrate the implementation of p* in MultiNet, and discuss various aspects of p* fitting with special types of data: large; symmetric; bipartite; multiple network. Since the program can handle up to 10,000 nodes and 256 parameters, managing the displays and reports can be quite complex. We demonstrate this with moderately large datasets.

Finally, we pull all of the pieces described and demonstrated in the earlier sections together and show how they work with the more complex types of analysis that we think is one of the program's strengths. We present a complex three-mode analysis problem that involves a moderately large, complex dataset from a medical study involving over 2,000 patients, 85 exposures, and 158 symptoms. We demonstrate an analytic strategy that allows more information about the network to be extracted from the data. To do this we use eigenspaces, several network techniques, hybrid variable creation and recoding, bipartite p* fitting, and network cross-tabulation – all together as a single, multi-stage analytic procedure.

Networks & Game Theory

Communication Structure, Network Effects, and Status Generalization

Geoffrey Tootell, Paul T. Munroe & Alison Bianchi

Earlier findings (De Kelaita, Munroe, and Tootell 2001) suggest that self initiated person to person transfers of status characteristics can occur in status generalization processes. Communication structure can facilitate network effects which lead to status transfers. This also implies that status characteristics theory (SCT; see Berger, Fisek, Norman, and Zelditch 1977) can account for some network effects. More-over, these transfers can generate or alter status differentiation in ways which may beget behavioral sequences with game-like situations in collectively oriented task groups (see Laing and Morrison 1974; Tootell, Bianchi, and Munroe 2000). Using an n-person cooperative game model devised by Swann (1991, 1980; Swann, Tootell, and Mason 1980), we designed an experiment which can provide evidence to show whether group members/players focus on task achievement or try to optimize between sufficient task success and status maintenance or enhancement. Existing evidence strongly supports SCT as a way to explain status generalization, so we first examine conditions familiar to SCT researchers to see whether players' behaviors satisfy predictions of the game model as well as of SCT. In other conditions we can discriminate between the two, to see if a game model gives a finer explanation of subjects' actions. SCT's scope conditions must be observed carefully or no such inference is possible. If evidence backs a game theory model, doors are opened (1) to seek other ways in which network structures may affect status

generalization or (2) to look for other ways network structures and/or game theory can be used to help explain relations among task achievement efforts, status, or power, and to study relations between SCT and traditions such as network exchange theory (see Willer and Skvoretz 1997).

Network Structure and Strategy Evolution in the Game of Chicken

Frank Tutzauer, Pauline W. Hoffmann & Margaret K. Chojnacki

Cellular automata have long been used to study self-organization, system evolution, and questions of dynamics and transformation. Beginning in the 1980s, researchers used cellular automata to study cooperation in the iterated Prisoner's Dilemma (PD). For these researchers, a cellular automaton is a lattice-like spatial grid consisting of interlinked cells. Each cell is occupied by an organism that adopts a certain PD strategy, and each organism plays the iterated PD with organisms in neighboring cells. After play, each organism decides to either retain its strategy or adopt that of one of its neighbors, depending on the relative success of the strategies. In this way, researchers study how cooperative strategies evolve based on the initial distribution of strategies and the make up of the population.

In this paper, we use a network approach to answer similar questions about strategy evolution in the game of Chicken, a matrix game that models phenomena as diverse as species competition, the California energy crisis, the NATO/Milosevic conflict, and the current war on terrorism. We make the natural identification between a network and a cellular automaton by equating cells of the automaton to nodes of a network, and considering two nodes to be adjacent if they are neighboring cells in the automaton. We label the nodes of the network with the particular strategies played, have each strategy play those strategies to which it is adjacent (in the network sense), and then change the labels on the basis of local strategy performance. Once we think of the strategies as evolving in a network, instead of in the classic spatial automaton, we can ask questions of structure. In this paper, we use theories of island biogeography to suggest various network structures, and for each network structure we conduct computer simulations to determine the evolution of strategies in the network.

Networks and Culture

How to Read an Institution: A Structural Approach

John W. Mohr, Michel Bourgeois & Vincent Duquenne

Since 1995, the University of California has been prohibited from employing affirmative action principles in student admissions. In response to this constraint, the UC has sought to pursue a number of other avenues for promoting the selection and retention of a diverse student body. In this paper we look at how officials and staff within the UC system have sought to develop an alternative rationale for managing the categorical problem of identifying types and classes of applicants along with strategies of action that stay within legally allowable frameworks. We argue that a new framework for organizational action has emerged (a cultural logic) which is made up of a dually ordered system of identity categories and institutional activity categories. We use Galois lattices as a way of unpacking the dynamic emergence of this new organizational logic.

Micro-Cultures: Network Effects on Conversational Sequences

David Gibson

Networks rarely strike us as cultural, but that is because we tend to gloss over the way in which network structure is activated and experienced "on the ground," where culture is to be found. An important component of culture consists of the way in which network structure is translated into situational behaviour. Insofar as this translation occurs differently in different settings, each involves a distinct "micro-culture." Here I examine the translation of formal and informal organizational networks into conversational actions in a range of managerial groups. Because conversation is subject to endogenous constraints on how many people can speak at once, and on permissible transitions, this involves looking at the way in which people operate through and around these constraints to "enact" their network ties. This is achieved through a monte carlo analysis of the extent to which fleeting conversational connections are "stacked" on top of pre-existing networks. The analysis reveals that while groups had some translation patterns in common, they differed with respect to others, and thus with respect to the micro-cultures they sustained

Musical Tastes Unwarped

Shin-Kap Han

Using the W-MDS method, which takes advantage of the special feature of the data on Musical Tastes in the GSS Culture Module (NORC 1993), I generate a multidimensional structure of preference from the data. The structure provides a way to understand and specify musical tastes with more nuance and rigour. Musical tastes, the preliminary analysis suggests, vary along three separable evaluation/distinction dimensions — in addition to "Like-Dislike" dimension, "Intense-Diffuse" and "Familiar-Unfamiliar" dimensions (cf. Levine 1993). The like-dislike dimension is what most researchers have focussed on thus far. The results show, however, that it is those at the low end of the education hierarchy who differentiate musical genres primarily in those terms. At the opposite end, to the contrary, the importance of like-dislike dimension is diminished: What matters more are the other two dimensions. (Bryson's finding in "Anything But Heavy Metal" (1996), for example, seems to be the result of the particular genres falling on the wrong side of the spectrum on all three of the dimensions. People not only dislike them, they are rather familiar with those and dislike them intensely. The congruency, though, is not the rule.) In light of these findings, I reconsider the notion of "omnivore" (Peterson and Kern 1996): It might not be about the large number of genres they like per se; rather, it might be more about switching the evaluation/distinction schemes. Also examined are the network- structural implications of these two views on omnivore (Erickson 1996; Mark 1998; Han 2000). Finally, I relate the findings to the conceptualization-operationalization debate on cultural capital (Bourdieu 1986; DiMaggio and Mohr 1985; Lamont and Lareau 1988).

Projects and Pathways: Organizational Trajectories and Narratives of Political Engagement

Ann Mische

In this paper, I explore how "projective narratives" — our cognitive and emotional maps of the future — are influenced by trajectories through multiple intersecting worlds. As Schutz and Mead argue, actors continually reassess future possibilities in the face of past experiences; such projective (re-)evaluation takes place

as they pass through what Simmel calls overlapping "social circles," composed of sets of interpersonal and organizational ties as well as temporal narratives that project collectivities backward and forward in time. While recent work has examined the sequential patterning of temporal trajectories, this work has failed to explore the cultural correlates of such trajectories in terms of projective narratives; moreover, this work has not addressed the effects of multiple involvements — existing simultaneously as well as sequentially organized over time. This paper examines processes of project-formation among Brazilian youth activists in the mid-1990s, as influenced by trajectories through overlapping organizational sectors (e.g., student, religious, partisan, professional, business). I draw upon 350 questionnaires documenting activists' histories of organizational participation, as well as demographic information and their personal and social projects for the future. This quantitative data will be used in conjunction with in-depth interviews in order to locate different "trajectory profiles" (i.e., where activism begins and in what order and/or combination it proceeds). I will examine how different organizational pathways are related to different ways of constructing narratives of possible futures, as well as how a sense of personal future becomes intertwined with — or separated from — the collective futures articulated by organizations..

New Directions in the Study of Networks and Culture

Ronald L. Breiger

In four papers presented at the "Networks and Culture" session of the 2002 Sunbelt meetings the authors (Mohr et al., Han, Gibson, and Mishe) open up an important new direction for network analysts. Some key components of the new "cultural turn" in network studies include the relation of cultural logics to social structure, the relation of identity categories to organizational and institutional action, the relation of cultural to social capital in the profiling of tastes, the examination of "micro-cultures" in which networks are translated into conversation and action, the intertwining of narratives with memberships and projects, and methods for the study of the duality of cultural representations and local social practices. Current analytical challenges and prospects for future development are emphasized.

Knowledge Networks: Intra-organizational

Exploitative and Explorative Learning Through Networking Strategies Within a High-Tech Industry Setting

Bonnie Beerkens, Geert Duijsters & Wim Vanhaverbeke

Learning through networks has been a research topic for several years now. In high-tech industries, companies are technologically learning on a continuous base in order to become or to stay competitive. Technological learning is based on a combination of internal and external learning – internal learning by the internal development of new products and processes as a result of internal R&D, external learning from the technology acquired through technology based strategic alliances.

We are particularly interested in the distinction between exploitative and explorative functions of external technology acquisition. We utilize the contingency approach suggested by Burt (1998) to analyse the linkage between the explorative and exploitative types of learning in external technology acquisition: through (internal technology development and) external acquisition of technological knowledge firms may deepen their core technologies or they may broaden their technology base. Companies deepen their existing technological capabilities to ensure current revenues and profits, but they simultaneously try to enter new and promising technological fields to generate profit streams related to the commercialization of new technologies.

We claim in the paper that the 'type' of strategic alliance used by companies is related to the type of learning. Weak inter-organizational ties are powerful in finding and valuing novel information (I) because they are less likely to generate redundant information, (ii) they are less costly than strong ties, and (iii) they escape the inertia inherent in the existing network relations of a firm. As a result, if the main aim of a company is to broaden its knowledge base the use of weak ties (or bridging ties) will be more effective.

Finally, we also have a look at the inter-organizational absorptive capacity (Lane and Lubatkin, SMJ, 1998). It is very difficult to absorb externally acquired technology. This is particularly true when the company has no acquaintance with the targeted external knowledge field. External acquisition of technology will be more effective in broadening the knowledge base of a company if the newly entered technology field is related to the core technology of the company.

Network Position and Individual Performance: The Relationship Between Inter- and Intra-Organizational Knowledge Flows and Individual Performance in the Internet Consulting Industry

Robin Tiegland

With the rapid penetration of internet-based communications worldwide, individuals are now able to communicate efficiently with others regardless of time and space. Thus, when knowledge workers seek help with their work-related tasks, they may just as easily contact individuals working in rival firms located across the globe as an individual working within the same organization sitting at the next desk. In addition, the internet has greatly facilitated the ease with which individuals can informally trade (send and receive) codified know-how in the form of reports and data with individuals both within and outside their own firms. Thus, the purpose of this study is to examine whether individual performance (both creative and effective performance) varies as a result of 1) the individual's position in the co-located organizational network, 2) the individual's position in the geographically dispersed organizational network, 3) participation with individuals in the task environment (e.g., supplier, partner, client, and consultant) 4) participation with individuals in the external environment (e.g., internet communities, friends, etc.), 4) intra-organizational know-how trading, and 5) inter-organizational know-how trading. Data for this study have been collected at Icon Medialab, a multinational internet consulting firm considered typical of "New Economy" firms. Using an intranet-based survey, data were collected from 1450 individuals (76% response rate) across the company's 29 offices in Europe, Asia, and the United States. Preliminary results indicate that creative performance is significantly related to participation in communities in the external environment and inter-organizational know-how trading while effective performance is related to the individual's position in the co-located organizational network and intra-organizational know-how trading.

Intraorganizational Social Influence During Implementation of an Information System (Research Proposal)

Zuzana Sasovova

With the rapid penetration of internet-based communications

worldwide, individuals are now able to communicate efficiently with others regardless of time and space. Thus, when knowledge workers seek help with their work-related tasks, they may just as easily contact individuals working in rival firms located across the globe as an individual working within the same organization sitting at the next desk. In addition, the internet has greatly facilitated the ease with which individuals can informally trade (send and receive) codified know-how in the form of reports and data with individuals both within and outside their own firms. Thus, the purpose of this study is to examine whether individual performance (both creative and effective performance) varies as a result of 1) the individual's position in the co-located organizational network, 2) the individual's position in the geographically dispersed organizational network, 3) participation with individuals in the task environment (e.g., supplier, partner, client, and consultant) 4) participation with individuals in the external environment (e.g., internet communities, friends, etc.), 4) intra-organizational know-how trading, and 5) inter-organizational know-how trading.

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Market Knowledge, Social Capital and Absorptive Capacity: An Analysis of Knowledge Spillovers Within Marketing Departments

Christophe Van den Bulge, Annouk Lievens & Rudy K. Moenaert

This paper investigates how marketing professionals' intra-departmental social network is associated with their knowledge about customers, competitors, and technology. There are three findings. First, we find no consistent effects for ego-network density or central brokerage position, the two network characteristics that have dominated social capital research. Second, however, we find stronger effects for social network exposure, i.e. access, to others' knowledge, a rather under-researched facet of social capital which we model using network autoregression. These two findings support recent conjectures that brokerage positions and trust need not always lead to superior outcomes and that, in some contexts, social capital is better conceived as access to others' resources. Our third finding is that individuals' extant knowledge has a positive effect on learning from peers in the technology domain, but a negative effect in the customer and competitor domains. This suggests that the professionals studied were realizing positive returns on their own intellectual capital for learning outside their primary task environment, but negative returns for learning within their primary task environment.

Understanding, Recognizing, and Enhancing Communication Networks

Simulation Models of Information Flow in Small Networks: Design, Analysis, and Graphical Representation

Wolfgang R. Sodeur

Following an idea (and program) of William Sims Bainbridge (1987: Sociological Laboratory. Computer Simulations for Learning Sociology. (Wadsworth) Belmont, Cal., Chapter G: Invent) a more general simulation model was developed.

The general functions of Bainbridge's model remained unchanged: A group of 9 actors has to solve a problem, i.e. has to find a word with up to 10 letters. They do so partly by means of individual actions (looking for single letters, trying to combine letters to find the solution word) and partly by interactions (communicating about letters already known). However, the options for the experimental design are increased now: Letters are looked for with different degrees of activity by those actors who are able to "invent" (experimenter's decision). Actors try to transmit letters along given communication channels with different intensity (experimenter's decision). And they change their communicative behaviour to other actors following their prior experiences and special rules of interpretation (experimenter's decision). The simulation model allows to design, run and analyse communication processes flexibly under a variety of situations. Examples are:

(1) The relative "strength of weak ties" (Mark Granovetter) in different situations of network structure and labour division among actors.

(2) The relationship between structure and efficiency of problem solving in small (non face-to-face) groups (Rolf Ziegler; Lee S.Christie; Alex Bavelas).

(3) The structural development of communication nets due to the local experiences of "rational" actors which follow alternative rules of interpretation (Rolf Ziegler).

The analysis of results may concern intermediate or final results (cross sectional analysis) as well as process data (time event analysis). Examples for both will be presented by means of simple statistics as well as graphical representation of the developing structures. Following an idea (and program) of William Sims Bainbridge (1987: Sociological Laboratory. Computer Simulations for Learning Sociology. (Wadsworth) Belmont, Cal., Chapter G: Invent) a more general simulation model was developed.

Enhancing Social Networks Through Email

Andrea Lockerd & Ted Selker

Computer-mediated communication (CMC) opens up new possibilities in the maintenance of social networks. Examples include the ability to visualize networks in real time, monitor the flow of resources, and facilitate network maintenance. This presentation discusses the design and implementation of an electronic mail system that facilitates users awareness of their electronic social networks. This system models what different relationships and socioemotional qualities "look like" in terms of email characteristics. Built through statistical analysis of a hand labelled email corpus, this model enables the system to characterize and display new email in network terms. Some examples include: tie strength, symmetry, foci of activity, and kinds of social support. Visualizing various network features helps the user become aware of their network and adds a social context to online communication that is not present in current email applications.

Organizational Communication Networks: New Methods and Future Directions

Devan Rosen & Sung-Choon Kang

This paper highlights the application of network analysis to reveal organizational structure via communication linkages using Donald Schwartz' original liaison communication dataset (1968). In this paper a unique five-step method of measuring Simmelian ties (Krackhardt 1992) is introduced using valued relational data. The similarity of the perceived and demographic data across three dimensions, Simmelian ties, structural holes, and degree centrality, not only support the original research but also provide unique insight. It was found that degree centrality had a positive correlation of 0.464 with Simmelian ties and a negative correlation of –0.687 with constraints, setting centrality as a good predictor variable of both. Surprisingly, structural holes (constraints) were found to decrease as tenure increased in an educational context. This finding is explained as a combination of level of seniority of respondents and general organizational structure. The ability to retest the information in the data collected by Schwartz is a testament to his methods and the richness of the dataset. Future directions explore the applications to online communities as clusters of activity around message topics or threads.

An Examination of Network Structures For Information Retrieval in Transactive Memory Systems

Edward T. Palazzolo, Noshir S. Contractor, Andrea B. Hollingshead & Douglas Steinley

This paper explores an organization's communication structures from the vantage point of Transactive Memory Theory. Transactive Memory Theory explains how individuals learn who knows what (i.e., identify experts in various knowledge domains) and allocate and retrieve information to support and utilize these experts (Wegner, 1987). A transactive memory system is comprised of three primary relations. The first relation, Perception of Other People's Knowledge, includes each actor's perception of what other actors know in different knowledge domains. The second relation, Communication to Allocate Information, is a communication relation based on actors sharing unsolicited information with their co-workers. The final relation, Communication to Retrieve Information is based on actors requesting task specific information from others to complete their work. A well-developed TM system has many benefits for the team members including access to more information and reduced cognitive loads (Hollingshead, 1998). The network of teams is analysed using p* statistical techniques (Contractor, Wasserman, & Faust, 1999; Crouch & Wasserman, 1998; Wasserman & Pattison, 1996). The analysis identifies which structural tendencies are most prevalent in the Communication to Retrieve Information relation for work teams. To learn what best explains a retrieval tie between two actors, the retrieval relation is analysed at multiple levels: the actor level (e.g., the tendency to chose other actors in the network), the dyad level (e.g., the tendency for actor I to choose actor j when actor j chooses actor I), and the triad level (e.g., the tendency to form transitive triads). Additionally, actor attribute information, such as an Individual's Knowledge, is considered with respect the retrieval of information between actors. Finally, the retrieval relation is analysed with respect to two other relations between the actors: Communication to Allocate Information and Perceptions of Other People's Knowledge.

Intercorporate Network Dynamics

Inter-firm Influences on Adoption of Novel Business Practices

Mary C. Still & David Strang

We examine the conditions under which interorganizational relationships are necessary to spread novel business practices that differ substantively by innovation issue area (i.e., quality, work/life, the internet). Using data from a global financial firm's benchmarking process in which 236 firms were benchmarked over 13 issue areas, we investigate the extent to which ties and firm attributes influence adoption of novel practices. We find the effect of such firm characteristics as size, sales, age, and expertise in the innovation domain surprisingly small, while general firm reputation and ties between the focal firm and benchmarked firms are more influential. Tie types and innovation characteristics matter, however: direct ties, measured by senior management exchange, are more influential in issue areas that are untheorized, complex, and in which the firm has little expertise. Indirect (competitive) ties are influential when issue areas are perceived by benchmarkers as related to strategic advantage and when the firm excels in the issue area. We argue that new measures of interorganizational linkages may be more promising for understanding innovation decisions than the often-used directorate interlock measure, especially when the innovation decisions do not directly involve directors or are only pro-forma by the time they reach the board.

Revisiting the power: Changes in the Spanish structure of economic power (1991-2000)

Josep A. Rodríguez

Some years ago we studied the social structure of the Spanish economic power at the beginning of the 90's, using inner-circle and network approaches. I used interlocking data on the 100 most important corporations. At the beginning of this century I am returning to the power centre studying again relations (through interlocking directorates) among the now 100 most important corporations and between their board members. In this paper I compare the resulting two corporate power structures and the two inner-circle structures to assess structural similarities and differences, survival of board members and corporations, and the role of the survivals in the new structures. The nature of the structural changes poses questions regarding the transformation process as well as their effects. Changes in the centre of corporative power are not exclusively the result of internal power forces and struggles but they are also the consequences (as much as the enhancers) of changes in financial markets at large and in the orientation of the economic power. These transformations are linked to the fast globalization of financial markets we have witnessed during the past decade.

The Strength of Strategic Networking in Resource Accumulation: Internal Dynamics and Network Effectiveness

Zhiang Lin & Dan Li

From a social network perspective, this study intends to explore how the underlying dynamics of a strategic network (SN) may affect its effectiveness for resource accumulation under different network conditions. Using computer simulation, we model the SN as a group of purposeful firms that interact with each other

based on resource match and prior exchange experience, reflected through the strength of their network ties. Such a SN is then contrasted with a random network (RN), which is modelled as a loose collection of member firms with no preferences for partners in resource search and accumulation. The simulation results show that, in general, the SN is more effective than the RN in resource accumulation, although the uncertainty level of the resource environment faced by the member firms and the size and centrality of the network can generate divergent influences on such effectiveness advantage. This study suggests that the benefit of a SN may ultimately lie in its members' ability to learn from the information embedded in their ties.

Learning or Fad Following: Board Embeddeness and Technological Change

Sreenivas Rajan

I look at the impact of organisational embeddedness in one network, the board interlock network on the position of the organisation in another network, the technology network. I investigate primarily two mechanisms, which link the organisation's position in the board network and the technology network. The first mechanism is an organisational learning mechanism, where organisations deploy and utilise the social capital of their directors to learn about technological change, reduce technological uncertainty and maintain or improve their position in the technology network. The second mechanism I investigate is a neoinstitutional mechanism, where in organisations through their boards look at structurally equivalent or prominent organisations and in a taken for granted quest for legitimacy follow the strategic and technolological moves made by these organisations. The empirical setting for the study is the network industry. This industry has gone through tumultuous period of change and to add a further layer of empirical complexity, has at the time of writing this paper gone through a traumatic and unprecedented collapse. To add to the empirical interest, this industry is being continually shaped by the technological forces, which are leading to the erosion of boundaries and the convergence of the information technology industry with the telecommunications industry. I use panel data estimation to analyse data collected from patent citation and board interlock databases, on an initial sample of 32 firms collected over a period of seven years from 1995 to 2001. Results indicate support a view of boards using their embeddedness both to learn and follow the latest fad, though neo institutional mechanisms are more dominant.

Making of the International Market

The Emergence and Expansion of Transnational Corporate Networks 1957-1998: An Organizational Network Perspective

Jeffrey Kentor

This work traces the emergence and expansion of transnational corporate networks between 1962 and 1998. I identify the linkages between the headquarters of the 150 largest manufacturing corporations and their foreign subsidiaries in 1962, 1971, 1983, 1991 and 1998. We then aggregate these linkages by country. Measures of density and centralization are calculated to chart the expansion of the world-economy. I also chart the shifting centrality of individual countries. Finally, I consider the relationship between in-degrees and out-degrees as a measure of network power in the world-economy.

Social Structure and Economic Networks: Stable and Dynamic Embeddedness in an Early Modern Stock Market

Bruce G. Carruthers & Xiaoli Yin

Network analysis methods have been frequently used to study contemporary markets, but rarely markets from the past. Consequently, little is known about the social structure or embeddedness of pre-20th century markets. Following a sociological embeddedness argument we propose a non-uniform market structure, with people unevenly distributed between centre and periphery. We also propose that people who were socially peripheral outside the market would also be on the periphery of the market. We analyse data on trading in East India Company stock from 1712 to study the early modern London stock market. Particularly, we examine centrality to map out the market network. We also correlate network features with other social characteristics, including gender, social status, politics, religion and ethnicity, to see how the stock market was embedded in larger social structures. We found that the stock market possessed a distinct centre and periphery structure, and traders were not uniformly distributed throughout the network. On the one hand, we found that the patriarchal relationships between subordinate women and supra-ordinate men appeared both in and outside of the stock market. On the other hand, we found that the stock market was heavily influenced if not controlled by social and religious outsiders, such as Jews, foreigners, and non-conformers. Therefore, the stock market reflected external social structure in ways that both reinforced and contradicted British society. To account for this, we distinguish between stable and dynamic embeddedness.

Transnational Policy Networks: EU Enlargement and Social Policy Diffusion in Poland and Hungary

Beate Sissenich

Recent debates on transnationalism credit networks of non-state, state, and intergovernmental actors with the ability to increase the political leverage of non-state actors at home. The assumption is that the greater the number of ties among intergovernmental, state, and non-state organizations, the greater is the likelihood that domestic non-state actors are able to influence policy in their country. However, the focus on positive cases may have led analysts to overly optimistic assessments of the effects of transnational networks. Reference to “networks” in metaphorical rather than empirically measurable terms may also have obscured the presumed causal relationship between transnational ties and domestic leverage. My analysis of the network around European Union social policy and enlargement shows that even in a most likely case, trade unions and employers’ associations have not obtained greater domestic influence through their dense set of transnational connections. The paper presents network data on 32 actors that are theoretically relevant to the transfer of EU social policy to Poland and Hungary and shows that domestic non-state actors are on the whole well-connected to EU institutions, European confederations, and state actors. But qualitative data show that these extensive transnational ties have not led to an increase in the political leverage of Polish or Hungarian trade unions or employers’ organizations via regular consultation with the government.

Historical Network Analysis

Narrative Networks

Peter Bearman

To what extent should historians consider chance and contingency as critically important in developing narrative accounts of historical event sequences? How can historians gain confidence that the events that they consider important are actually important, without simple recourse to judgement? This paper considers some strategies derived from developments in network modeling to solve these and other core problems in historical analysis. The central idea is to represent a historical narrative as a graph, and to utilize methods for analysis of graphs to reveal properties of historical event sequences.

Credit in Renaissance Florentine Markets

John Padgett; Discussant: Roger Gould

4000 debts among Florentine firms, coded from the 1427 catasto, are analysed in order to understand both the structure and the social production of commercial credit in the Renaissance.

A Methodology for the Quantitative Study of Event Narratives (PC-ACE Program for Computer-Assisted Coding of Events)

Robert Franzosi

My talk will focus on a methodology of systematic data collection from newspapers on protest events and a computer program that I developed in the 1980s : PC-ACE, Program for Computer--Assisted Coding of Events. I have used the program to code some 16,000 newspaper articles on the 1919-22 period in Italy, leading to the rise of Fascism, and another 16,000 newspaper articles on the 1986-87 period on the difference between industrial and service sector conflict. I illustrate the use of the new Windows-version of PC-ACE with the data collected on the 1919-22. I show how the relational properties of the data (centered around the basic linguistic template of subject-action-object) make these data ideally suited for a network analysis. I show the results of network models applied to the 1919-22 data.

Social Networks and Political Parties in Chile

Larissa Adler Lomnitz

This paper describes the origin and evolution of two Chilean political parties (the Radical Party and the Christian Democrat Party) through the analysis of the social networks that originated and composed them. The aim of this study is to propose a model of national political cultures on the basis of the structure of social networks related to power and of the symbol system, which legitimizes it. The structure of social networks, horizontal and vertical, are based on reciprocal or redistributive forms of exchange, on what is being exchanged and on the articulation between networks. In every society there are symmetrical and asymmetrical exchanges, which produce horizontal and vertical networks. These networks interact among themselves to form the social fabric. The dominance of some over others and how they combine, delineate the character of the political culture (authoritarian vs. egalitarian). Chile is a multiparty country within which there are cohorts of horizontal groups of friends, who informally exercise a central control over their members and create invisible boundaries setting them apart from others, in which leadership is under constrains. The result is both a strong presidential system based on an almost fanatic legitimacy, combined with factionalism and a strong parliamentary system.

The Dynamics of Power and Social Networks: Evidence from Post-Socialist Russia

Andrew D. Buck

Although there has been considerable advancement in the study of power and position in a social network, little research has addressed the dynamics of this issue empirically. This paper develops a dynamic conception of a person's structural capacity in social networks from an in-depth case study of community elites during Russia's transition to democracy, 1993-1999. Drawing on insights from sequence analysis, the research examines shifts in the city's coalitional structure during the competition for political office. The results show that loyal partisans liquidated coalition builders in a process of polarization. Loyal partisans adopted coercive and, at times, violent political technologies, such as forced removal and assassination, to eliminate coalition builders from political office. The results suggest that escalating antagonisms between rival factions disable 'brokers' as leaders because their commitment to any single faction is ambiguous and non-transparent.

Three Mexican Presidents and Their Corresponding Cliques

Jorge Gil-Mendieta, Samuel Schmidt & Jorge Castro y Alejandro Ruiz

The Mexican network of power achieved a remarkable record on political stability. The creation of a network's strong and cohesive centre helped the network control the fundamental political processes and institutions: mainly the presidency. The six year Mexican presidential term determines political careers, however, the cliques might increase or decrease membership influencing its centrality. In this paper we analyse the evolution of different cliques over a 50 year period. We focus on the creation of cliques were three presidents belong and compare how they evolve in an 18 year period.

Political Networks: Comparative Perspective

Thirty Years of Organizational Communication Network Research at Michigan State University: 1968-1998

Alex Susskind, Donald F. Schwartz, Bill Richards & J. David Johnson

In this paper we document the 30-year history of communication network research that emerged from the Department of Communication at Michigan State University starting in 1965 with Don Schwartz and ending in 1996 with Alex Susskind. We are referring to Don and Alex as a "pair of book-ends" because they represent the starting and ending points of the communication network tradition at MSU. From MSU, Bill Richards and Dave Johnson are the nodes that connect the two bookends from 1968 when Don graduated to 1991 when Alex arrived as a graduate student. There were many others in between the bookends and many interesting developments during that 25 year "middle period" at MSU. Between the four of us, and the help of many others of course, we were able to form a continuous set of direct links from one end of the bookshelf to the other. We have traced and documented the history through personal recollection and personal interviews of those on or near the "bookshelf, "and have extended prior to 1965 and following 1996 to show how the network tradition started and how the network tradition has

shifted from MSU. Ironically Schwartz and Susskind both ended up at Cornell and were introduced to one another in 1998. They met while Don was preparing to retire and Alex was starting as an Assistant Professor. The two bookends met, completing the network circle.

Network Density and the Organization of Social Identities

Dawn T Robinson

Sociologists' conceptions about the link between social networks and social identities have focussed primarily on linking the content of the network to the content of the self structure. For example, work on Identity Theory (e.g., Stryker 1968, 1980, 1994) specifies a causal relationship between network based commitment to certain self-components (identities) and our likelihood of activating those identities (salience). This theory posits a direct relationship between our social ties and our activation of specific identities on which those ties depend. In this paper, we consider additional ways in which our networks of relationships influence the social identities that comprise our self structures. We argue for an expanded consideration of both network structure and self structure in considering this relationship. Drawing from research in social networks, social identity theory, and group processes, we offer a series of predictions about the relationship between network structure and self structure. Then, we present the results of two studies that experimentally tests one of the predicted links, namely, the relationship between network density and self complexity.

Specifically, we examine whether individuals who find themselves in partially connected communication networks express more and more varied self-information to communication partners than do individuals who are in fully connected communication networks. We use an experimental method in which respondents describe themselves during conversations with simulated partners through a computer mediated communication network. Participants are told that they will interact in a computer network with three other partners whose computers are either (a) connected to each other's, as well as to the subject's computer (fully dense network), or (b) connected only to the subject's computer (sparsely connected network). We find that participants in the sparse network condition express a wider variety and a greater number of identities than participants in the fully dense network condition.

Networks in Tragedy: Communication and Response to the World Trade Centre Attack

Lynn Smith-Lovin

We use data from the National Tragedy Study (a random telephone survey of 2126 U.S. residents conducted by NORC after the World Trade Centre and Pentagon attacks of September 11) to look at how people heard about the event, who they contacted after hearing the tragic news, and how the social context in which they heard the news influenced their emotional and behavioural response. Some comparable data are available from another national tragedy: the assassination of President John F. Kennedy. We find that mass media continue to dominate the spread of such news, but that personal contacts constitute a substantial minority of transmissions. Internet and email do not play a major role. We examine hypotheses based on an affect control theory treatment of collective identity formation (Heise 2001) about the relationship between being with others while hearing about the events and emotional reactions.

Communication Networks and Attitudes

The Effects of Friendship on Attitudes Towards the Environment: Clique Membership and Social Resonance within Larger Groups

William B. Stevenson

It has become an accepted social fact that network ties are an important component in the social context that affects the attitudes of individuals. Common clique membership or structural position defined by network ties has been shown, for example, to lead to common attitudes among individuals. What has been considered less often is the possibility that those sharing ties within cliques embedded in a larger group have more "social resonance" or commonality of outlook with the larger group as compared to more isolated members of the group. Data was collected on friendship ties and attitudes towards the environment in a number of classes at a university. Some evidence was found for social resonance based on clique membership and a number of propositions for further research are proposed.

Communication Causes Consolidation, Clustering, and Continuing Diversity

Bibb Latané

Experiments with people exchanging electronic messages in predefined networks reveal three emergent consequences of communication: 1)Consolidation, as adherents of minority positions are converted to the majority viewpoint, 2) Clustering as people become more similar to their neighbours, and 3) Continuing diversity as clustering limits consolidation by shielding minorities from adverse influence by encapsulating them in like-minded neighbourhoods. Computer simulations of the complex dynamics of influence in these communication networks using a simple theory of social impact successfully predict the level of each of these phenomena under a variety of circumstances.

Embedded Intercorporate Networks

The Problem of Collective Action Among Small Firm Owners: The Case of Shopkeepers in a Portuguese City Centre

Marta Varanda

This paper is concerned with the analysis of two initiatives to modernize the city centre commerce in a medium sized town in Portugal. One of these initiatives is a government program encouraging shop remodelling through attribution of financial incentives (up to 66,6% of their investment) to individual traders. The other initiative is an extension of Saturday opening hours from 1 p.m. to 7 p.m. - a change launched by the local trade association in order to face competition and re-direct consumers away from large surfaces and back to the centre. These two situations are different in character but share similarities in that they a) both call for a change in practices and have an innovative character – even if they are different in terms of levels of financial risk; and b) their success depends on the massive participation of traders. However, traders' participation was low (did not reach 30% in both initiatives).

This paper tries to understand this incapacity in coordination

of action by looking at the overall network characteristics, and the socio-economic attributes, of small firms and their owners, as well as their relational behaviour (discussion relations). We interviewed 192 traders- at the end of 1998 and beginning of 1999 – just before the modernization program started, and while the Saturday afternoon openings were already under way. Multivariate logistic regressions lead us to think that one important factor accounting for the participation in collective action was the social integration of firm owners, measured by their degree centrality and by their involvement in cohesive subgroups.

These results suggest that coordination of economic strategies to revitalize city centre commerce is based on the level of social inter-dependence among firm owners. This is of utmost importance as it implies a need to depart from the established rules of the game: in this professional group, the basic rule and most valued weapon has been secrecy of business strategy. Engaging in dense relations and coordinating with old competitors – their neighbours – is perceived to represent a loss of power over their businesses. Most are not ready to accept this. Lacking a strong leadership and a common normative framework towards participation in collective action, mechanisms of mutual control and enforcement of sanctions will not be put in place, and widespread participation cannot be expected.

The Embeddedness of Social Ties and Cooperative Behaviours Between Competing Organizations: Social Mechanisms and Social Structure

Marco Tortoriello & Vincenzo Perrone

This paper investigates the underlying mechanisms at work behind the broad concept of embeddedness. While this theory helps us understand why standard neoclassical schemes are only partial accounts to the explanation of economic phenomena, the knowledge of how social embeddedness fills this gap is still far from being complete (Uzzi, 1996, Portes and Sensbrenner, 1993). Past research has often pointed out the relevance of such social processes as information exchange or interorganizational trust but only seldom has systematically investigated these as causal mechanisms that help explain economic action. Are different social ties all playing the same role in the definition of individuals' economic Behaviours? Does it matter if ties are reciprocal or not? Are both the sender and the receiver of a given tie necessarily in the same position in the market or status differences would predict different outcomes? These are the principal questions that I will address in this paper.

Using a unique dataset on the network of social ties defined among 72 hotel managers clustered in the same local area, I will consider reciprocal, non-reciprocal and indirect social connections assessing their relative contribution to the development of cooperative strategies. Controlling for a number of variables that would predict cooperation according to other non-social rationales (e.g. market similarity, prices, size, services, etc.), I will look at interpersonal trust, exchange (mutual and not) of information and acknowledgement of social status among the managers of 72 hotels to see how and to what extent they predict overbooked client referrals. Preliminary results show a significant and positive impact of reciprocal and indirect social ties on the decision to cooperate, over and above the prediction of rational economic predictions. Non-reciprocal connections turned out to be not significantly related to cooperative Behaviours. Theoretical and practical implications for future research are discussed.

The Ties That Make the Market: An Empirical Study of the Organization of Production Relations

Alessandro Lomi & Philippa Pattison

One way to think about markets is as collections of independent agents interacting only indirectly through price information. An alternative way to think about markets is as communities of agents each interacting with, and reacting to every other. Empirical observation suggests that reality typically stands in between these analytically convenient polar extremes. But more realistic representations of the organizational structure of markets come at a price because intermediate situations require the development micro-level assumptions about how participants interact, and about their location across multiple networks. Using data on different types of relationships among 106 organizations involved in the production of means of transportation located in Southern Italy, in this study we document how macro-organizational features of producers' markets emerge out of the concatenation of different types of local ties among individual producers. Starting from relatively weak assumptions about basic principles of organizational bonding, we analyse the rich variety of ways in which observable patterns of interorganizational division of labour produce and reproduce organizational features that are observable at more aggregate levels. In the discussion we emphasize the implications of our results for comparative studies on the network structure of organizational communities.

Corporate and Inter-organizational Networks

The Small World of the Corporate Elite

Gerald F. Davis, Mina Yoo & Wayne E. Baker

Elite studies in the U.S. have long argued that the American corporate elite comprises a "small world" of mutual acquaintances, facilitated through shared board membership, who come to share similar world views and standards for appropriate action. There is, however, less consensus regarding the conditions necessary for the emergence and the maintenance of the small world. We take advantage of the recent advances in the theoretical and methodological tools for analysing network structures to examine the network properties of the directors and boards of the several hundred largest US corporations in 1982, 1990, and 1999. We show that the structures of the networks for the directors and companies are sustained over time despite major changes in corporate governance and organizational structure and the marked decline in the economic significance of commercial banks. Based on our findings, we suggest that the "small--worldness" of the corporate elite is the result of neither conspiratorial design nor strategic response to the environment but of the intrinsic properties of the networks themselves.

The Role of Policy Planning Organizations and Social Clubs for the Small World of the Corporate Elite

Roy C. Barnes & Steve Ward

This paper explores the small world of the corporate elite in the United States in 1962, 1973, 1983, and 1995. Through the construction of two-mode affiliation networks, our analyses initially explore the changing social space between many of the largest U.S. corporations and the individuals constituting their boards of directors during the second half of the Twentieth Century. However, the sharing of corporate directors is only one

component of America's power structure. To more fully capture the multifaceted nature of the power structure in the United States, we next document the role that policy-planning organizations such as the Business Council and Committee for Economic Development play in forming links between the directors and the corporations for which they serve as board members. Finally, we add an additional layer of social affiliations, this time utilizing the ties formed by common membership in exclusive social clubs. In short, the small world of the corporate elite is even smaller than one would be led to believe on the basis of interlocking directorates alone

The Small Word of the Australian Corporate Elite

Malcolm Alexander

This paper examines the network of personal contacts among the board members of the top 500 companies in Australia. The network of personal contacts among board members is a function of the local clustering of boards combined with the connections among boards created by interlocking directorates. In the past it has been difficult to analyse such sparse networks. An emphasis on connectivity, rather than density, and the 'small world' analysis of Duncan Watts provide new tools for analysing these sparse networks, primarily characteristic path length (average geodesic distance). We also propose a measure of scope: the number of 2nd degree contacts of each person. We use these measures to compare corporate elite networks from 1976 and 1996. We then look at individuals who score highest on these measures.

Networks of Banks and Industry in the Netherlands 1976-1996

Meindert Fennema, Eelke Heemskerk & Rob Mokken

In this paper we analyse the networks of interlocking directorates among the 250 largest Dutch corporations in 1976 and 1996. The network in 1976 was a relatively thick and centralized network in which the banks were the central hubs. Twenty years later the network had become much thinner, banks played a less prominent role in the network even though they remained important hubs. The number of direct multiple connections of the financial institutions with industry decreased substantially and they became more dispersed. Overall the number of interlocks decreased with almost 40 percent. This leads us to believe that the finance capital model that was still in vigour in 1976 does not hold any longer in 1996. The Dutch network has become sparser, but its connectivity has not decreased. We conclude, therefore that the network has become more efficient as a communication network, while the aspect of corporate control has diminished. These changes can be interpreted as a shift towards a shareholders model of corporate governance.

The Network of Global Corporations and Elite Policy Formation: A Small World?

William K. Carroll & Colin Carson

This study situates five key transnational organizations of elite consensus-building within the larger structure of corporate power that is constituted through interlocking directorates among the worlds largest companies. These policy groups have served as sites for the construction of a new hegemony both by building consensus within the global corporate elite and by educating publics and states on the virtues of one or another variant of the neoliberal paradigm. Yet each has its own history and occupies a distinctive niche in the organizational ecology of transnational neoliberalism. Our analysis proceeds from the premise that those who direct the world's largest corporations are the leading edge of a ruling class that includes major capitalists as well as the organic intellectuals whose advice, as outside directors, is sought by various companies. Empirically, we explore three research questions surrounding the participation of this corporate elite on the directorates of such global policy groups as the Trilateral Commission and World Eco nomic Forum:

1. Who are the people at the centre of the corporate-policy network — those whose multiple board affiliations constitute much of the transnational structure? How do their group affiliations create a structure of relations among the policy groups?

2. At the level of organizations, what is the basic shape and form of the interlocking directorships among the world's largest corporations and the global policy groups?

3. What contribution do the global policy groups make to transnational corporate-elite integration?

The point of the analysis is to investigate one dimension of transnational capitalist class formation, with an eye toward what the network tells us about the structural sources of elite integration as well as possible tension and contradiction.

Mathematical Networks

The Erdos Collaboration Network and Bose Einstein Statistics

Aparna Basu

In a recent paper, Bianconi and Barabasi have shown that there is a link between evolving networks and Bose Einstein statistics in quantum mechanics. Bose Einstein behaviour and Bose condensation are collective phenomena observed at very low temperatures and microscopic dimensions, e.g. superconductivity and superfluidity. The connection is therefore unexpected, as the networks considered by them were large macroscopic networks, such as transportation networks and the World Wide Web. The networks were assumed to evolve through the introduction of new nodes that attached to existing nodes through the creation of links. The existing nodes competed for new links in terms of some fitness criteria and level of current linkages. By defining nodes as energy levels and links as particles, a mapping to a BE distribution was obtained. We ask here whether the same principles could be found to be applicable to a social network? We consider the network of collaborators of mathematician Paul Erdos in his work spanning seven decades. The frequency of multiple collaborations with 507 co-authors is found to be a power law relationship. We show that the probability of such a network arising from random classical forces is minuscule as compared to the Bose Einstein probability. The reasons why this unexpected quantum result could be seen, and the implications of such a result are discussed in some detail in terms of the competition for links.

Random and Biased Net Theory: A New Approach

John Skvoretz & Filip Agneessens

Random and biased net theory, introduced by Rapoport in the 1950s, is one of the earliest approaches to the problem of formally modeling social networks. In this theory the ties in a population derive both from random and non-random events of connection. The non-random events of connection are generically known as bias events. The types of bias events proposed in a particular model are designed to incorporate known non-random tendencies in tie formation. These tendencies include forces toward mutuality or reciprocity, toward transitivity or closure in triads, and toward over-representation of ties between persons

who share important socio-demographic attributes like race/ethnicity or level of educational attainment. Development of the biased net approach, however, has been stymied by the lack of analytical tractability: derivations are difficult to make without dubious approximation assumptions and model parameters are difficult to estimate. In this paper, we propose and develop a fresh approach to biased net theory, one that begins with efforts to derive some standard distributions of structural configurations, such as the dyad census and triad census. The end result is a highly general formulation that encompasses all possible biased net models. We show how earlier formulations amount to a specification of a particular model within this framework.

An Improved Mathematical Foundation for Centrality

Ulrik Brandes

The standard normalization scheme for centrality indices on networks is applicable only to certain combinations of indices and networks. With this scheme, for instance, closeness centrality cannot be normalized on directed networks. We therefore introduce a generalized normalization framework for arbitrary networks. Our framework agrees with the standard scheme whenever the latter is well-defined and suggests new ways of utilizing centrality and related indices. Moreover, it provides the basis for a better understanding and more rigorous characterization of families of indices and their underlying assumptions.

Social Capital: Theory, Method, and Evidence

The Invisible Hand of Social Capital: A Theoretical Exploration

Nan Lin & Amelie Quesnel-Vallee

It is often assumed in the research literature that the use of interpersonal contacts in the job mobility process should provide advantageous returns in the labour market. However, most individuals report methods of job search other than the active use of interpersonal ties. In addition, the use of informal methods appears to be more prevalent among members of disadvantaged social groups, and does not consistently achieve better outcomes (see recent reviews: Lin, 1999; Marsden and Gorman, forthcoming). These puzzling findings may mean that social capital has little impact in the mobility process. We propose a theoretical explanation to resolve this puzzle and sustain the argument for the utility of the social capital in the mobility process – the invisible hand of social capital. Evidence indicates that individuals in advantageous social positions are embedded in resource-rich networks. We may hypothesize, therefore, that the routine interactions they engage in also contain richer or more useful information – including information about the job market. That is, richness of embedded network resources is associated with the usefulness of the routine flow of information and shared knowledge about labour market opportunities. Following the homophily principle, we further hypothesize that richness of embedded network resources is also associated with the propensity to exert influence on behalf of one another and thus with the likelihood that individuals be approached for job opportunities. This latent process, thus far not measured in empirical studies, would account for the patterns observed until now, namely that individuals in more advantaged prior positions are less likely to indicate active use of interpersonal channels in job searches and yet enjoy better job opportunities and outcomes. In addition to developing a theoretical framework and providing some tentative evidence, this paper will set agenda for future research investigations into the invisible hand of social capital.

Should I Stay or Should I Go? Social Capital and Promotions Within and Across Firms

Raymond T. Sparrowe & Pamela A. Popielarz

We offer a comprehensive test of the influence of social capital on career mobility, controlling for industry dynamics and human capital. We focus on two aspects of informal social networks: structure and racial composition. Our approach is explicitly dynamic, using event history methods with time-varying covariates. We hypothesize that structural holes and racial diversity in career networks increase promotion rates within and across firms. Testing these hypotheses in a sample of hospitality industry employees, we find that structural holes in career networks significantly increase the rate of promotions across firms, while the racial heterogeneity of career networks significantly increases the rate of promotions within firms.

The Resource Generator: Social Capital Quantification with Concrete Items

Martin van der Gaag & Tom Snijders

Measuring individuals' social capital has basically been pursued following two methodological paths. First, the 'name generator/interpreter' approach (McCallister and Fischer, 1978), where measurement of the ego-centered social network is a starting point for a subsequent social resource inventory. This can result in very detailed and informative social capital descriptions, but the collection of such data can be tedious. Second, the 'position generator' approach (Lin and Dumin, 1986), in which the basis for measurement is formed by items concerning access to network members' occupations, representing certain positions in an hierarchically structured society. The administration of this method is easier, and can be more systematically adjusted for different populations. However, it retrieves more abstract social capital representations in terms of social prestiges and ranges. Snijders (1999) has therefore proposed measurement combining aspects of these methods, with item sets referring to the availability of concrete resources from social network members. In this instance, social capital measurement with such a 'resource generator' is investigated for a representative sample of the Dutch population, as included in the 1999-2000 'Social Survey on the Networks of the Dutch'. This includes an investigation of the internal correlation- or dimensional structure of this instrument, and the eventual proposal of resulting multiple social capital measurement scales.

Navigating Through Intraorganizational Networks

Gender Differences in Social Networks in a Scandinavian Context

Christian Waldstrøm

As an increasing number of women enter managerial positions in organizations today, still too little is know about the role of their social networks in the workplace compared to their male colleagues. Relying on previous work on the gender differences in managers' social networks in organizations this paper uses the results from a large scale survey of Danish managers to test whether the propositions from earlier work can be supported in a Scandinavian context. Thus the underlying theme for this

paper is the possible influence of national culture when studying Danish managers based on a mainly US-based theoretical framework. The findings might the have broader European implications. The primary findings in this paper show that while male and female managers do not show significant differences in the importance they place on managerial competencies, there are some quite distinct differences in the importance they place on those competencies associated with informal leadership and social capital: Female managers place significantly higher importance to the social networks than their male colleagues and female managers are more likely to develop dual social networks within the organizations, while male managers tend to have just one social network. While the first finding is rather surprising, the second finding is in line with prior research. The data was collected as part of The Danish Management Barometer (2000) encompassing more than 1000 Danish managers and leaders. In this analysis only managers in the private sector are included. The data analyses are performed using a profile analysis and several factor analyses.

The Effects of Self-monitoring and Network Position on Role Conflict, Role Ambiguity, and Workplace Stress

Mark T. Schenkel, Ajay Mehra & Daniel J. Brass

Our study examines the effects of personality and network position on role perceptions in the workplace. Using data from a 116-member high-technology organization, we tested how self-monitoring orientation and structural position in the friendship and workflow networks related to role ambiguity, role conflict, and stress. First, high self-monitors experienced greater role conflict and stress than low self-monitors. These effects remained significant even after network position in the friendship and workflow networks was controlled. Second, individuals who connected otherwise unconnected others in the workflow network experienced greater stress than those who worked with inter-connected individuals, but network position had no effect on role perceptions. The results underscore the value of combining personality and network variables in explaining workplace outcomes.

Social Networks in Academic Institutions – A network Analysis

Anne Bøllingtoft

Network analysis has recently become an increasingly accepted tool for organizational analysis, as it allows for studying interesting social interactions within as well across organizational boundaries. In this paper, a social network approach is used to examine interactions of formal and informal networks in a department of an academic institution. Data was collected in autumn 2001 bye means of a structured questionnaire among researchers at an academic research department in Denmark. The department is characterized by a number of unique and interesting features: (I) most of the members of the department also work in a research centre (23 out of 35); (ii) the department is located in three different buildings; (iii) due to lack of funding, the research centre is currently facing number of problems resulting in an unsettled future. This situation is hypothesized to make the social networks more important in the organization. A network analysis has been used, offering an opportunity to produce important insight into the degrees of centrality, reach and centrality of key actors. Given the special features of the department, the analysis of such complex webs of social interactions and contacts holds promises to give some important indications of the structural aspects of the communication flows within a department. In line with previous research, our results suggest that both the frequency and contents of communication is dependent on geographical location of the researchers. Furthermore, there are strong indications that work related issues are most often discussed with male colleagues by both men and women in the department. Also in regards to which personal matters are discussed, there are indications of differences between genders since the male researchers seem to have a larger network than their female colleges. In closing, the paper will address implications for research, managers and other relevant decision makers.

Strategic Networks in Educational Organizations: An Examination of Administrator Networks in Public School Districts

Julie M. Hite, Ellen J. Williams & Steven C. Baugh

Informal and social network relationships strategically influence an organization's effectiveness. In educational organizations, educational administrators grapple with unseen forces that are inherent within these influential, informal networks of relationships. However, their lack of awareness of these networks can lead to failed attempts at accomplishing educational aims. The problem is that when administrators lack awareness of the informal network system and its potential effects, they are less able to strategically assess, monitor, and maintain this critical network of the organization. This lack of awareness may inhibit organizational performance, particularly in terms of both administrative and educational objectives. Yet, educational research has not yet examined or addressed administrator networks in a substantive or holistic manner. This case study research presents an initial examination of the internal organizational network of public school district administrators. The study, framed within the paradigms of qualitative methods and building upon strategic, organizational, and network theory, incorporates case study and survey research methods within the larger framework of network analysis to address the following two research questions: 1) To what extent is previous network research relevant for the strategic context of public school districts? 2) What is the informal network structure of public school district administrators? and 3) What are the strategic roles of the internal network of public school districts? The study finds that four distinct networks exist among the school administrators: 1) innovation, 2) social/emotional support; 3) critical resource acquisition, and 4) resource provision. The discussion focuses on the strategic roles of each of these network structures for the performance of educational organizations.

Scholarly Networks: Changes in Scholarly Work: Interdisciplinary and Technology

The Influence of Interdisciplinary Scholarship in the Humanities: a Citation Network Analysis of Ethnomusicological Literature

Michael Frishkopf

Interdisciplinary is a catchword of postmodern humanistic scholarship. But one expects both inputs (sources) and outputs (influences) of interdisciplinary research to represent multiple disciplines. The former is easy; the latter harder. Interdisciplinary fields certainly draw on diverse sources; the question is whether they make interdisciplinary contributions. Since the 1950s,

ethnomusicology, positioned at the inter-section of humanities and social sciences, has produced a large literature. A self-declared interdisciplinary field, ethno-musicological literature offers a good case study within a more general examination of humanistic interdisciplines.

In this study, I investigate the influence of ethnomusicological literature on non-music disciplines, by analysing the cross-disciplinary network of citations traceable to that literature. To what extent has ethnomusicology contributed to the humanistic and social science disciplines upon which it regularly draws? How does it compare to related areas of scholarship in this regard?

Using ISI's Web of Science, I analysed citations to articles published in a core ethnomusicological journal (Ethno-musicology) from 1980 to 1995, and in key journals of ethnomusicology's cognate fields (in music and anthropology), computing a recursive concept of "influence": if B cites A, then the influence of A via B depends on the number of citations in B, the length of B, and the influence of B. Summing, one calculates the total influence of any particular article, breaks out that influence by discipline, or averages over all articles. The results indicate that while ethno-musicology is highly interdisciplinary on input, its outputs are self-feeding to a surprising degree. Various explanations for such self-referentiality, not necessarily related to the quality of the published work, are proposed. While criticism of facile computation of influence based solely on citation networks is salutary (Edge 1979; Case and Higgins 2000), quantitative citation analysis remains a pragmatic first step towards a constructive critical investigation of humanistic interdiscplinarity.

Networks in Cancer Research: Do Conceptual Barriers Build Knowledge Structures?

Tiffany Tummino

Several conceptual models of cancer coexist within the scientific, medical, and policy communities. While not usually contradictory, they drive different types of research, and can have different implications for priorities and practices in medicine and public health. The recent and rapid spread of microarray technology, used to test biological samples for the expression of up to thousands of different oligonucleotide strands, has altered the face of cancer research. Integrating the resulting deluge of molecular information with our present understanding of cancer, choosing research strategies to expand it, and determining how it will be used in the medical and public health systems are the next steps. The way these tasks will be accomplished is intimately connected with the types of conceptual models that exist and the relationships between the people who sustain them.

My current project is to capture the way that array technology is impacting research-groups' models of cancer and how these changes affect the representations of cancer that eventually propagate to the public health sphere. Here, I examine co authorship and co citation networks among researchers. These networks are combined with information on the researchers' conceptual models as evidenced in their publications. The analysis will likely show clusters of researchers who share similar, but not identical, models. An exploration will follow of the relationships between the size, density, diversity, and connectedness of subgroups and their members' propensity to express ideas and approaches in a manner that achieves coherence with those of other group members by emphasizing shared structures and bundling problematic distinctions into conceptually flexible abstractions of the underlying epistemic objects. These analyses will be used to explore the idea that researchers who interact professionally despite different concepts of cancer surmount this difficulty by negotiating a system of generalized representations to encompass specific points of divergence; and that these intermediary representations, despite their initial role as mere communication devices, may ultimately shape the body of shared knowledge that distinguishes the public face of a scientific subfield.

Interdisciplinary Knowledge Exchange

Caroline Haythornthwaite & Douglas Steinley

This paper presents preliminary results of research exploring the nature of exchanges in interdisciplinary knowledge work. A questionnaire was used to collect network data on types of knowledge-related interactions by interdisciplinary scientific researchers with their close set of coworkers. The researchers are all members of teams specifically created to foster interdisciplinary research.

Knowledge relations were explored with the five to seven co-workers they have worked with most frequently in the past six months with attention to those who were considered to be in the same or a different discipline, and those in and outside the interdisciplinary research team. Questions explored work exchanges (what researchers did with each coworker), and learning networks (what they learned from or got help on from each coworker, and what they believed the coworker learned or got help on from them). Questions also asked about work products, including who they had worked with on something particularly new or creative, and with whom they had created products such as data collections, computer programs, research analyses, or writings. Results will explore the types of exchanges that researchers engaged in, and how such exchanges differ with those considered to be in or not in the same discipline, and in or outside the interdisciplinary team.

Traditional and Innovative Practices Building Social Networks in the Techno Science Domain

Christiana Soares de Freitas

New information technologies have been changing practices in almost all spheres of social life. The production and circulation of scholarly work has also been significantly affected. Researchers in the areas of education and media production, for instance, are implementing a challenging project: the first electronic journal to conduct a peer review process online, in a public space, where any individual interested in the discussions that take place is able to contribute and influence in some way the substance of any given article.

The group responsible for this new communication medium has established new social norms and practices within the web space of the journal. But will these innovations survive? Can they be considered indications of the emergence of a new mode of knowledge production that is underway as researchers have been claiming (Gibbons et al, 1994)? Or will they revert to traditional evaluation methods used for centuries in the scientific field? This paper will demonstrate how traditional and innovative practices are combined in this new reality, either promoting changes in evaluation procedures or incorporating features originated in the traditional peer review process.

Social Network Analysis has been used as an important method for analysing the development of research networks throughout the years (Wasserman & Faust, 1994). With this conceptual and methodological approach it is possible to verify interesting features such as the density increase in communication patterns in the open virtual peer review as well as similarities and differences between online and offline relations. In this

sense, the research evaluated to what extent transformations in virtual space affect physical reality and at the same time express it. The analysis identified an interweaving process of causes and consequences affecting rules and practices between these different spheres related to the production and circulation of knowledge in the technoscience domain.

Methodology: Data Mining

SocioMetrica LinkAlyzer

Allen Tien, Geoff Ott & Svetlana Cheshmedjiev

We would like to present SocioMetrica LinkAlyzer, a software program which is designed to use attributes such as gender, age, physical features, Behaviours, etc., to match subjects in a data set who may be the same person. These matches are then collapsed into a single subject, and linkages are inherited, creating a sociometric data set. LinkAlyzer was used with actual data from a sample of subjects at risk for drug use and HIV. Results suggest the validity of this approach. Virtual networks, constructed through matches that may not represent actual matches, are also of interest.

Group scope: Data Mining Tools for Online Communication Networks

Dean Krikorian & Greg Ludwig

This paper provides a demonstration of Groupscope, a data mining tool that uses social network algorithms to observe communication patterns in asynchronous Internet groups over time. The paper uses the Cornell Communication Network Analysis Laboratory's Internetwork measures (Krikorian, 2001; in press, forthcoming) of online group communication and combines these with Web spidering techniques to explore network patterns over time. Featured are the Internet Group Communication Boxscore and the Group Microscope and Telescope which serve to provide both micro and macro visualizations of online group communication. The use of data mining and other statistical techniques on large datasets using Internetwork measures are explored in this paper, including the ethics of collecting such data in various online contexts such as newsgroups and Internet clubs. Future directions examine the role of data visualization over time, synchronous communication, and spatial distance measures in graphical chat environments.

Data Mining in Networks

Jennifer Neville & David Jensen

Classification in very large networks of heterogeneous objects and links is an important area of research with many applications, including epidemiology, fraud detection, and systems analysis. In this paper we outline a compositional approach to classifying objects in networks using Proximity, a system for relational knowledge discovery (http://kdl.cs.umass.edu/ systems/ proximity/). The approach uses a novel variant of a simple Bayesian classifier (SBC) that learns a classification model from network data. SBCs learn models that predict the class of one object (X) based on 1) intrinsic features of X, 2) features of the objects and links in the local neighbourhood of X, and 3) structural features of the network. SBCs are used frequently in the machine learning and data mining communities for propositional data because they are efficient to learn and easy to understand. Although SBCs make the simplifying assumption that features are independent given the class, it has been shown that SBCs produce optimal predictions of class labels even when this assumption is violated by a wide margin (Domingos and Pazzani, 1997). As illustration, we present results for various classification tasks in the Internet Movie Database (http://www.imd b. co m/) , a network of one million objects and over three million links, including movies, actors, directors, producers, studios and awards.

Epidemiology

Social Network Characteristics and Concurrent Alcohol and Drug Use Among Homeless Youth

Peggy L. Peterson, John S. Baer & Joshua Ginzler

The importance of peer and social network influences on adolescent alcohol and drug use has been well established. Homeless youth have substantially higher rates of alcohol and drug use than their same-age peers. Yet, little is known about the social networks of homeless youth. Understanding the characteristics of these networks and how they are associated with risk behaviour among this population is particularly compelling given that many of these youth live outside other sources of potentially positive influence, namely school and family. In this presentation, we will describe social network characteristics of 280 homeless youth (N=100 for preliminary analyses) ages 13-19 who were recruited from agencies and street intercepts as part of an ongoing study evaluating a brief drug risk-reduction intervention among homeless youth. Personal network data were collected for up to 10 network members and included age, gender, relationship, where known from (e.g., street, school), how long known and whether the person was an injection drug user or a sexual partner. Ratings were also obtained for relationship closeness, social support (material aid, emotional support), contact frequency and, alcohol, marijuana, and other drug use frequency. Preliminary analyses revealed that median network size was 10. Only four respondents reported two or fewer members. Ratings of network social support were high. Greater involvement in the street drug environment, and having fewer outside ties, were associated with greater drug risk behaviour of respondents measured as number of drug use days in the past 30 days. Sub-group analyses suggested that current injection drug users' (IDU;33%) networks tended to be smaller, older, largely comprised of people from the street and contain a smaller proportion of family members compared to non-IDU. Results will be discussed in terms of protective and risk components of homeless youths' social networks and implications for risk reduction interventions.

Social Network Influences on Needle Use Among High Risk Youth and Young Adults

Cynthia M. Lakon & Susan T. Ennett

Injection drug use Behaviours are inextricably connected to the social interactions that occur in the social networks of injection drug users. Mechanisms by which social networks influence injection drug use have not been clearly elucidated and existing literature suggests the importance of understanding them. This study will investigate mechanisms through which egocentric social networks may influence needle use Behaviours associated with HIV transmission. The proposed mechanisms of influence are social regulation of needle use Behaviours and social support. The study will examine the mediating roles of social regulation and social support in explaining the association between various network characteristics and needle sharing and cleaning. The network characteristics include structural (i.e., size and density), interactional (i.e., multiplexity and closeness of network ties),

and normative (i.e., network norms around needle use and network injection drug use) characteristics. The proposed work is a secondary analysis of data collected from a study undertaken to understand the HIV risk and protective Behaviours of young women and their peers, ages, 15 to 23, who are either injection drug users and/or their sexual partners. A total of 320 people participated in the study. This study was conducted using a cross-sectional design and field interviewers conducted face-to-face structured interviews. Respondents named up to four people with whom they injected drugs and answered a variety of questions about these people. These data are used to form egocentric networks. Tests for determining relationships among constructs, mediation, and interactions will be conducted using logistic or multiple linear regression, depending on the scale of the outcome variables. Age, gender, race/education, and education will be controlled for in these analyses.

Social Networks and HIV Knowledge: Protective Factors for High and Moderate Risk Older Adults in Senior Residential Units

William B. Disch, J. J. Schensul & R. N. Radda

Evidence indicates that older adults living in public housing are highly vulnerable to the effects of drugs and alcohol, violence, and assault. In addition, epidemiological data demonstrate that HIV/AIDS risk in older adults is more common than previously believed, with unprotected sex being a significant route of infection. Data from a current NIA-funded study of HIV risk among senior housing residents in Hartford, CT and Chicago, IL indicate that in addition to being at a higher risk for consequences related to alcohol, drugs, and violence, sexually active older adults engage in unprotected intimate Behaviours with single and multiple partners, including commercial sex workers, despite awareness of HIV/AIDS-related risk. Participants with the highest sexual risk behaviour did not have significantly lower HIV/AIDS knowledge scores. Results from network analyses show that the larger in-building social networks function as protective barriers against risk associated with high-risk individuals. However, the analyses also indicate that strong prevention oriented building networks do not necessarily provide personal protection from negative consequences of high-risk sexual behaviour (e.g., HIV/AIDS, other STDs). In addition, the results indicate that a combination of knowledge and attitudes about HIV/AIDS and a false sense of security related to social network configuration leaves older adults that are sexually active at high risk for HIV/AIDS and other STDs. This paper will present these findings with implications for intervention.

Social Capital and Structural Change

Access and Mobilization: Social Capital and Top Management Response to Market Shocks

Martin Gargiulo & Andrej Rus

We formulate and test a model of social capital that conceptualizes the context in which actors operate along two dimensions of uncertainty: uncertainty about ego's access to resources and information and uncertainty about the mobilization of actors controlling those resources and information. We apply our model to studying the effectiveness of chief executive officers (CEOs) in helping their organizations to respond to external market shocks. Using a representative sample of Slovenian CEOs, we show that, after controlling for the firm's exposure to the market shock caused by the separation from Yugoslavia in the early 90s and for the level of prior exports to Western economies, CEOs who could rely on a cohesive top management team and whose networks were relatively more focussed on their external ties rather than on their contacts inside the firm were better positioned to increase sales to the domestic or Western European markets, thus dampening the negative impact of the separation from Yugoslavia. On the contrary, firms whose CEOs either chose or were forced to focus the attention on their top management team instead of on their external ties were less able to recover from the market shock. In addition, we show that, for firms facing strong competition in the domestic market, external networks rich in structural holes enhanced their sales performance.

Personal Networks and Social Capital in Times of Change: Examining Social Network Resources of Germans During the Decade After Unification

Jan H. Marbach

The paper will propose an analytical concept of social capital using repeated survey and panel data on ego-centered networks. The concept, then, is applied to empirical network data of adult Germans who at the beginning of the sampling period lived in the former German Democratic Republic and Federal Republic of Germany. As sampling came to its second and third sweep unification had taken place bringing "transformation stress" mainly to bear on East Germans. This is the socio-historical background of some questions to be answered in the paper: If ever, how did social change in the wake of unification impact personal networks of both East and West Germans? Have there been significant differences of social capital between East and West Germans due to a special transformation impact on East Germans? If so, did differences shrink or grow during the post-unification period? How were differences modified by inner-German migration? Data base is the Family Survey conducted by the German Youth Institute (DJI) in charge of the German federal government. The Family Survey includes three sweeps, the first having taken place in 1988 in West Germany and 1990 in East Germany immediately after unification, the second in 1994 covering both parts of Germany simultaneously, and the third in 2000. Repeated sampling was accompanied by panel interviews in the second and third surge.

Social Networks Go To Market: The Effect of Structural Change on Social Capital

Sarah Busse

Social capital, or social network resources, is embedded in social, economic and political conditions, and therefore susceptible to change in any of those structures. This paper examines the effects of marketization and democratization on individual-level social capital in the transition from state socialism in the Russian Federation. Based on ethnographic data from participant observation in a large Siberian city in 2000, the paper describes effects on post-Soviet social capital in three organizational settings in the third sector (a university, a church, and a small voluntary association). Findings from this qualitative research suggest that social capital is affected by structural change in three primary ways: 1) through changes or potential changes in network structure; 2) through changes in the resources available in existing social networks; and 3) through changes in the way

networks themselves are mobilized, that is, how networks function for social capital in this context. The paper also indicates ways individuals invent, adapt or resist new uses for social networks or new Behaviours for utilizing their social capital in problem-solving strategies. Change has been positive as well as negative for local residents. All three settings examined provide evidence of new social network opportunities created as a result of systemic change, while all three settings also demonstrate the destructive potential of the market and democracy for networks established during the Soviet era. As marketization introduces an increasing gap between rich and poor, access to social network resources are also becoming increasingly unequal, affecting future stratification patterns in Russian society.

Politics Through Network Intraorganizational Networks and Theories

Self-Determination Theory and Structural Control

David Dekker

In structural hole theory a major assumption is that individuals are homogenous in their motivation to use entrepreneurial opportunities. In this paper we relax this assumption and employ self-determination theory to develop an hypothesis on the interaction between the structural environment and motivation. When individuals see themselves as causing the events in their environment they are said to have an autonomous orientation. Individuals with such orientation have been found to be more intrinsically motivated. On the other hand when individuals see the locus of causality in their environments they are said to have an control orientation. Such individuals have been found to be more extrinsically motivated. We hypothesize that when the structural environment fits an individual's orientation better, this will positively affect the success of that individual. That is, autonomously oriented individuals will perform better when they operate in network structures with many structural holes, i.e. in which they hold broker positions. In contrast, control oriented individuals perform better in networks that provide high constraint. Within a European division of a large global accountants firm we gathered network data and financial performance data to empirically test these hypotheses.

An Integration of Network and Media Richness Theories of Turnover in Organizations

Marya L. Doerfel & Mirit Shoham

This project integrates employee isolation and turnover with social information processing and media richness theories to extend network theories of turnover in organizations (Daft & Lengel, 1984; 1986; Daft, Lengel, & Trevino, 1987; Feeley, 2000, Feeley & Barnett, 1997; Krackhardt & Porter, 1985; 1986; Rice & Aydon, 1991; Rice & Shook, 1990). We theorize that peripheral employees perceive a larger disparity between job-related information they receive versus what they need. That is, they have relatively greater uncertainty about various organizational topics than their more central peers. While a deficit of information should be assuaged by the employees seeking out information vis-à-vis richer channels (Rice & Shook, 1990), we hypothesize that the peripheral employees' channel uses will remain lean, reflecting an antecedent to their departure. On the other hand, the more central members, who may be characterized by information overload (Rice and Shook identify this as the need for "equivocality reduction"), reconcile their uncertainty through more rich media. The data were collected at three points in time from a small organization in the southeastern United States. Measures included social, task, and help networks, turnover, and the disparity between how much information employees received versus needed on various organizational topics, tasks, and channels.

Measuring Hierarchy

Lucio Biggiero & Roberto Dandi

This paper has two main goals. The first one is to extend Simon's definitions and to generalize Krackhardt's four conditions necessary and sufficient for a digraph to be an outtree, which is viewed as the archetypal form of hierarchy. According to Simon and Krackhardt the hierarchical condition is not an on/off condition, but rather a matter of degree. We can put at one extreme the outtree (or the star form), and at the opposite the non-directed all channel form as respectively the most and the less hierarchical organizational forms. Well, based on the analysis of the main measures of centrality corresponding to the outtree, we can identify a set of values of these indexes able to identify the archetypal form of hierarchy. Such indexes could be called "hierarchy markers". Then, we proceed weakening some of the characteristics of the outtree, in order to understand how hierarchy markers change. The elimination of directions of relations between points, that is the transformation of a digraph in a simple non directed graph, is especially helpful in understanding the "degree of hierarchy" in emergent networks. The second goal of the paper is to show what happens introducing relations between points in any of the three hierarchical level hypothesized (operating core, middle and top management). For instance, the creation of project (or product) managers corresponds to the establishment of such connections at the middle level. The analytical meaning of such changes is the introduction of redundancies in the network, while the organizational meaning is the de-hierarchization.

Networks and Adolescent Health

Using Social Networks to Prevent Smoking Pilot Test Results from a Network-based Smoking Prevention Program

Thomas W. Valente; Beth Hoffman, Anamara Ritt-Olson, Kara Lichtman, & C. Anderson Johnson

This study describes a network-based method for identifying peer leaders and assigning those leaders to groups based on sociometric distances. This technique was implemented in a school-based tobacco prevention program to determine if peer leader identification and assignment methods influenced program effectiveness. Past studies have shown that peer led programs are more likely to be effective than programs without peer leaders. However, there has been considerable variation in the methods used to select peer leaders, and assign students to groups. Preliminary analyses were conducted among 2,453 students in 81 classrooms. Results indicate that students in the network condition liked the program better than the random assignment and teacher conditions. Further, students in the network condition improved their resistance skills more and decreased their rates of intention to smoke compared to the other conditions. One year follow up data on smoking behaviour and other mediators will be collected in March 2002.

Longitudinal Social Network Analysis of Friendship Groups, Smoking and Drug-Taking using an Embedded Markov Process

Michael Andrew Pearson

Social network analysis is applied to three time points of a longitudinal teenage friends and lifestyle study carried out at the Medical Research Centre, Glasgow. The study examines, among other things, how smoking and drug use in adolescence is associated with social position within peer group structures. One hundred and fifty nine secondary second grade students in one school named up to six best friends, allowing for the categorisation of each adolescent as a group member, a group peripheral or a relative isolate. Building on previous work, which showed that the risk-taking behaviour of pupils on the periphery of peer groups reflected the behaviour within the groups, it is further demonstrated that transitions from non risk-taking behaviour to risk-taking behaviour occur predominantly at the peer group level of social position. The transitions of the pupils from time point one through to time point three are modelled in a Markovian way, so that the social position and risk-taking behaviour (or state) of a pupil at a certain time point is seen as being dependent on their state at the previous time point. It is found that there is a degree of predictability at the third time point in the expected number of pupils in the various sociometric states based on the transition probabilities derived at the second time point in one school. The expected length of time spent by pupils in the various transitional states is also modelled making use of an embedded continuous-time Markov process. The results testify to the importance of risk-taking peer groups, both as a source of influence and selection of peripheral members, and to the need for differential targeting by social status when intervening or delivering health education programs.

Understanding and Responding to Covert Networks

The Rise (and Possible Fall) of Networked Individualism

Barry Wellman

Until September 11, 2001 there had been a clear, discernible shift towards a society based on networked individualism. The boundaries of family, community, work, and state had become more flexible, permeable and multiple connected. There had been a shift away from locally-bounded communities and workgroups, from simple bureaucratic hierarchies, and from a two-bloc world. Is the United States' reaction to September 11 changing this. The physical boundary between the United States and the rest of the world has become more closed, especially hindering the free movement of people and goods. Air travel is becoming slower, more costly and filled with hassles. Fear of strangers may be leading to stereotyping and the withdrawal within socially and physically gated milieus.

Mapping Networks of Terrorist Cells

Valdis Krebs

This paper looks at the difficulty in mapping covert networks. Mapping networks after an event is fairly easy for prosecution purposes. Yet, disrupting covert networks to prevent criminal activity is much more difficult. We examine the network surrounding the tragic events of September 11th, 2001.

Through public data, we are able to map a portion of the network centered around the 19 dead hijackers. This map gives us some insight into the terrorist organization, and the social network metrics validate other data, yet we do not have a complete picture. Suggestions for further work and research are offered.

Types of Network Flows and How to (De)Stabilize Networks

Steve Borgatti

The standard discussion of how to stabilize or destabilize networks focuses on identifying structurally important nodes and lines and/or achieving certain network shapes. The validity of this discussion depends crucially on how things flow through the network. For example, networks of money flows have very different properties from networks of information flows. A given quantity of money can only be in one place at one time, whereas when information flows, it does so by transmitting copies. Consequently, the relative importance of nodes and lines is different in the two networks, even if they have the same structure. This paper lays out a typology of different kinds of flows and draws out implications for deriving measures of structural importance and for evaluating the desirability of different network structures. In addition, implicit assumptions about what happens when nodes and lines are added or removed are discussed.

Controlling Network Change: Stopping Adaptation and Destabilisation

Kathleen M. Carley & Ju-Sung Lee

The networks in which humans are embedded (social, knowledge, and task) are naturally dynamic. These networks form a meta-network. Natural change processes including learning, mobility, turnover, and birth/death alter these networks sometimes in ways that create cascades of change. For example, learning leads to changes in who knows what (the knowledge network) which leads to changes in who talks to whom and who can be assigned to what task and ultimately to who does do what task. By understanding how human networks naturally change and how changes affect different key outcomes such as information diffusion and group decision making, we can begin to control the process. In this paper, our understanding of network adaptation is used to answer two key control questions. How can you prevent adaptation, stall evolution and inhibit change so that you can predict how the network will respond? How can you destabilize the network so that its ability to respond is impaired? Insights into these questions are provided by examining the results of a computational multi-agent network model in which adaptive agents are embedded in social, knowledge and task networks which dynamically adapt as a function of agent behaviour. Two response outcomes, information diffusion and group performance, are considered. In doing the analyses a key concepts are the complexity of the meta-network, cognitive load, and the emergent leader. Results indicate that stressing the network inhibits but does not prevent adaptation. Further, these results suggest that social networks should not be examined in isolation. Predictions of how to control the network's behaviour based only on an examination of the social network are often wrong.

Personal Community Networks: Towns, Youth & Gangs

The Relational Bases of Everyday Life: The Social Network of a Small Town

Blyden B. Potts

The network pattern of specific interpersonal relationships is known to be important in the behaviour of a variety of (small) groups, and the importance of significant others to the behaviour of the individual is a core element of social psychology, yet models of lifestyle differentiation – perhaps because they remain more macrosocial – tend to emphasize causal variables that are either not relational or represent general rather than specific relational patterns (e.g. class). A network analytic approach to lifestyle differentiation is presented here, suggesting the importance of the pattern of specific social relations in shaping the distribution of everyday or lifestyle Behaviours in a community or society. Initial research findings from a study of networks and lifestyle Behaviours in a U.S. small town are presented. The overall network structure in which respondents are embedded is mapped as a composite of their ego networks. The equivalence of residents' positions in the network is tested as a basis for similarity or variance in lifestyle among residents, that is: in frequenting of certain stores, restaurants, parks, and places of worship; in leisure and other life activities; in temporal schedule; in geographic mobility patterns; in consumption of products and services; and in identifying with particular genres of culture and knowledge. The extent to which the population divides into relatively discrete behavioural clusters is assessed. Implications of these findings with respect to sociological concepts that address broad lifestyle differences (e.g. status group, habitus) are explored.

Expedient Construction of Affective Ties among Migratory Alternative Youth Networks

Lisa A. Romanienko

This paper examines one bounded youth alternative culture to explore the impact of body modification (particularly piercing and tattooing) upon social network formation. Using a financial flow approach within a transactional exchange paradigm, coupled with the foci of activity model; the analysis explores linkage creation within this community network through body modification services purchased. By examining the flow of revenue toward body modification businesses, the analysis provides insight regarding newly introduced actors attempting to make linkages within existing high status community networks. In addition to analysing the process of new linkage construction as strategic status attainment process, the paper also examines the frequency of contact, direction of initiation, strength of ties, and prevalence of reciprocating sentiments. The rapid development of informal networks, weakening familial support systems, and postmodern migration patterns are some of the factors discussed that provide evidence of the role of body piercing networks in the strategic process of status attainment among contemporary youth. Extending the foci of activity paradigm, she suggests that actors within modification networks often engage in specialized modification activities (such as body piercing and tattooing) with the specific intent of acceptance in social networks perceived as high status. Body piercing and other modifications as foci of activity, according to the findings, are not merely the impetus for constructing patterns of relations, but are strategic investments that are used to assure high status under temporary residential conditions in preferred community networks.

Immigrant Social Networks and the Structure of Constraints

Christine Avenarius

This paper investigates how the structure of immigrant personal networks constrains the process of their economic and social integration. Findings from ethnographic fieldwork in Orange County, Southern California show that the social networks of affluent first generation immigrants from Taiwan are not comparable to the densely knit, broadly-based ties linking neighbours and kingroup members attributed to traditional immigrants. Instead, the social networks of immigrants with high levels of human and economic capital are based on loosely bounded, sparsely knit, and dynamic specialized ties. Recent immigrants have local networks involving less kinship, but higher numbers of former classmates and members of joint recreational associations. However, space- and time-compressing technologies still afford opportunities to include ties with family and friends in Taiwan as well as in other places around the globe. Analysis is based on the assumption that heterogeneity in network composition decreases and homogeneity increases the likelihood of constraints regarding integration. While there is a tendency for personal networks to be homophilous (Marsden 1988), there is little information on the potential integration of individuals from different ethnic yet similar socioeconomic backgrounds into personal networks. This paper identifies the important structural constraints, including their origin and effect, that shape the formation of personal networks of Taiwanese immigrants and the degree of overlap created by these networks. Special attention is given to the implications of varying network structures for male and female immigrants on their sense of well-being and the different choices men and women make in building bridges to other social worlds.

Women's Gangs as Friendship Networks

Mark S. Fleisher & Svetlana Shinkareva

The common sociological (that is, variable-based) definition of a youth gang is a social group whose members commit crime. Implicit in this approach is that friendships are formed among gang members subsequent to gang membership, that gang members are friends with one another to a more-or-less equal degree, and that gang members' access to one another's resources (material, social, emotional) are shared equally among members. Extensive social network data were collected on adolescent, young adult, and adult women in a field study of women and gangs in Champaign, Illinois. The central hypothesis in this research is that (1) gang affiliation is independent of balanced support relations among friends (that is, high benefit, low cost relations will form and endure even between same-gang and different-gang friends) and that (2) a comparison of the friendship networks of women who are active and those who are inactive in gangs will show the termination of some relations in favour of others (independent of the gang affiliation) as women adapt to different life events, such as motherhood. Data show that women's friendships and the selection of friends for social support, affective, and instrumental support are independent of ego-alter gang affiliations.

Network Evolution, Careers, and Professional Communities

The Flow of Employment Information

Michael Francis Johnston

I use event history analysis to model the flow of employment information through social networks to workers searching for a new job. In Stage 0, workers were laid off from enterprises in Tianjin, China. In Stage 2, workers were asked about their social networks. In stages 2-5, workers were asked if they had received any employment information from people in their personal net-

works. Initial analyses revealed that conventional network measures (weak ties, high status contacts) were not predictive of receiving employment information more quickly than others. I am currently examining newer ideas, such as density (structural holes).

Centrality and Influence in the Semiconductor Industry Association: An Exploratory Study

Jennifer van Stelle

The intent of this study is to apply social network methods to historical data at the firm level for the U.S. semiconductor industry, to address empirically certain issues regarding the governance of the manufacturers' trade association, the SIA. This paper thus offers a preliminary network analysis of one of the major trade associations in the semiconductor industry. The main research questions upon which the paper focuses are: Which committees and firms have the greatest influence over the direction of the association? What might account for this? Were different committees and firms more or less influential at different time points in the association's history? What factors might affect their ability to make their influence felt? Data was gathered from eleven directories of the Semiconductor Industry Association, spanning the decades 1980-2000. A measure of centrality is used to explore firms' and committees' influence within the association over time. Working hypotheses address issues of associational governance and the changing influence of committees and firms over time, the correspondence of the association's stated objectives to the centrality of committees, and the interrelationship of firm centrality, membership type, and firm size.

The committee governance structure is clearly dynamic over time. In addition, it is found that institutionalist perspectives may further inform organizational research on trade associations. Steps for future research are outlined, including a board interlock study of semiconductor firms.

Maintenance and Reproduction of Academic Department Prestige

Scott L. Feld & Michael Bisciglia

The structure of relationships among PhD granting departments in Sociology is typical of the structure of relations in many academic disciplines. Nearly all faculty in Sociology PhD granting departments in the United States received their PhDs from these same departments. The network connecting departments to the departments granting their faculty PhDs has two distinctive properties that particularly foster the maintenance and reproduction of prestige levels: 1)Inequality of Outdegree, and 2)Correlation of Outdegree. Inequality of Outdegree is indicated by the fact that a very small number of departments granted the PhDs to a large proportion of the faculty of these departments. Correlation of Outdegree is indicated by a strong positive correlation between the number of PhDs a department has sent to other PhD granting departments, and the average number of PhDs sent by the alma maters of its faculty. While Hanneman (2001) promotes Bonacich centrality scores as indicators of departmental prestige, we suggest that outdegree itself is a simpler and better indicator. Nevertheless, the tendency for departments with high indegree (many faculty) to also have high outdegree combined with a high correlation of outdegree, leads Bonacich centrality scores to be relatively highly correlated with outdegrees. Furthermore, we show that the prestige is so over determined that several characteristics of departments provide decent indicators of prestige (e.g. proportion of faculty from top departments, and average prestige of the placement departments of the PhDs). Since most faculty are relatively stable over time, and outdegree depends upon characteristics of the overall composition of the faculty in all the departments, outdegree is necessarily slow to change, even in response to a dramatic change in the faculty of a department itself. We suggest that a good indication of changes in prestige is the number of recent PhDs placed in other PhD granting departments. However, the small numbers of new PhDs each year combined with the relative instability of untenured faculty make it necessary to consider longer time periods to be confident of any changes.

Reward Systems in Art

Wouter de Nooy

In the 1970s, sociologists drew attention to reward systems in science, religion, and the arts (e.g., Diana Crane in American Behavioural Scientist, 19 (1976), 719-734). The variety and continuity of cultural production, they argued, depended on the origin of the people who awarded the material and symbolic rewards and the type of standards they applied. Two properties of the reward system seem to be very important: (1) the fact whether a community of professional experts dominates the distribution of symbolic rewards, and (2) the opportunities to gain substantial income from the consumer market. Unfortunately, the concept of reward systems has not brought forth a rich tradition of research in the sociology of art. This is probably due to the fact that the continuity and variation of cultural production cannot be assessed easily. In this paper, the reward system is linked to a slightly different but related property of cultural production: the mobility of artists within an art world. Long careers indicate continuity and unlinked tracks of careers may show variation. In addition, previous research has shown that the mobility of artists reveals the prestige stratification of an artistic field, which is hypothesized to be more differentiated if symbolic rewards are awarded by a community of experts. Three art worlds will be compared: poetry, literary prose, and popular music.

Intraorganizational Networks and Performance

The Influence of the Social Network of Project Leaders on the Performance of Innovation Projects

Mats Lingblad

My dissertation research deals with cross-divisional innovation projects in large multinational firms. In these projects, it is difficult for the organization to rely on the existing organizational structure (division of labour) to provide an adequate structure. This is because the required knowledge and resources are often dispersed in the organization. I believe this is an interesting setting, in which to study the role of social networks. I am interested in the performance of innovation projects, but most of the explanatory variables are on the individual level.

The paper develops a structural model of innovation project performance. The full model encompasses three key types of actors involved in the innovation project. Project sponsors (members of the steering committee) provide symbolic and material resources to the project. Members of the project team are processing information and generating new knowledge. Finally, the project leader is involved in most activities of the project. The model also assumes three different types of interac-

tion flow in the relationships; information, influence, and social support. The current paper is Focussing on the project leader's network. Based on extant theory, the paper develops a few theoretically interesting trade-offs that the project manager has to deal with. One trade-off discussed concerns the density of the network. Existing theory would consider a sparse network to be beneficial for information. However, there is also support for a sparse network being detrimental for influence (as well as social support). Another trade-off concerns the relative importance of information and influence flows in the project leader's network.

The Performance of Action Groups as a Network Coordination Problem

Chris Baerveldt

In this paper a theory is presented to explain differences between the performance of action groups. Given external conditions such as the political situation, the public image, or the history of the group, some groups use their resources and people effectively, whereas others deflect completely. It is argued that these differences have to be explained dynamically, that is, by the way action groups adapt to changes in external conditions. The performance of action groups reflects the quality of the coordination of the three-dimensional network of members, tasks and resources, the MTR-network. The general adaptation problem is to reach consistency and consensus within the two-dimensional subsets of this network. Depending on the kind of external dynamics, action groups have to follow three different paths of adaptation through the MTR-network. Each path has its own specific adaptation problems. Some hypotheses are presented. For instance, it is argued why we expect that action groups cannot 'learn' to adapt, why all groups must die, and why a group ideology is an asset in one adaptation path, but a drawback in another.

A Social Network Perspective on the Dynamics of Group Performance: A Theoretical Framework and an Empirical Examination

Zhi Huang & Dan Li

Previous organizational behaviour (OB) research tends to examine group performance by Focussing on the effects of individual traits or their aggregates. Although this line of research has contributed greatly to our understanding of group Behaviours and their effects on group performances, what has frequently been ignored is the structural context of groups — the group network of relationships that knits everyone into interactions. The current study intends to explore the dynamics of groups and the determinants of group performance from an alternative view — the social network perspective. We first build a theoretical framework to examine the evolution of group network structures in terms of centrality and fragmentation and their effects on group performance, while interactions with group attributes identified in micro OB studies are also considered. We then conduct an empirical study based on a sample of 45 university student groups over a period of one semester. The results show that: a) group network structures do evolve over time but they are also influenced at the early stage by group attributes identified in previous research that are not static in nature; and b) group network structures can provide a stronger prediction for later stage group performance while group attributes can help predict performance at the early stage. Our study has demonstrated the importance of the social network perspective in understanding group dynamics. Implications of the findings for future research and practice are also discussed.

Social Capital and Community

What's Missing From This Community? A Network Analysis Approach

Maureen Kilkenny & Pedro G. Carvalho

What do thriving communities have that failing communities don't? Controlling for proximity to cities, transport, local endowments, and amenities, why do only some rural communities thrive? To answer this question we need to be able to identify not only the 'prominent actors' and the 'structural holes' (Burt) in community networks; we also need to be able to identify which entities and/or holes are responsible for what economic development outcomes. In this paper we address the first question by looking for patterns in the prominent actors and structural holes in the networks of nine communities. Three of the communities are in rural Portugal and six are in rural Iowa USA. Our direct surveys collected dyadic information over three relations: money, information, and support. Across the nine communities we compare (1) the overall network structures (2) the roles of prominent individual entities, (3) the blocked network structures, and (4) structural holes. We discuss similarities and differences between rural Portuguese and rural American small towns. We formulate testable hypotheses about the entities and ties that appear to be most the valuable for community vitality.

The Dynamics of Social Capital

Kenneth A. Frank

Social capital has been used to describe how individuals advance themselves by accessing resources through social ties, why resources are allocated through some ties and not others, and how resources are distributed throughout a system. These applications differ in the location of social capital and in the unit of analysis at which social capital is applied. These differences are reconciled in a dynamic conceptualization of social capital, drawing on the physical metaphor of a system that rotates to align internal resources to external opportunities. The system is propelled by actors' allocations of resources to each other. Actors who receive resources increase their capacities for action. Actors allocate resources to one another because of direct ties, or because they identify with the collective of the system. Identification is represented in the metaphor as a quasi-tie, linking actors to the focal point of the system. The stronger the quasi-ties, the more focussed the system, and the more rapidly it can rotate to align resources with external opportunities. Theoretical implications are tested in a study of the diffusion of computer technology among teachers in elementary schools. There is strong evidence that teachers' capacities to implement computer technology are increased by access to social capital. There is also strong evidence that teachers' identification with the collective affects their allocation of resources to others in a school. Finally there is moderate evidence that the manifestation of social capital increases teachers' identification with the collective of their schools. Only the term social capital adequately captures these dynamic theoretical processes and empirical observations. Therefore, all change agents must appreciate the social capital dynamics of any system with which they engage.

Creative Networks: Artists and Nonprofit Organizations in Community Building

Maria-Rosario Jackson & Joaquin Herranz, Jr.

The proposed paper presentation examines the inter-relationships between artists networks and neighbourhood-based non-profit organizations in forming informal to formal cultural partnerships. The research examines the role of the resulting community-based arts and cultural activities in forming social capital, revitalizing neighbourhoods, strengthening civil society, and enriching urban cultural vitality. The paper argues that conceptual and data limitations have contributed to an under-emphasis of cultural dynamics and network relationships in explaining such urban processes. At the same time, the authors argue that creativity networks are increasingly important to cities' quality of life and competitiveness due to transforming knowledge-based economy global trends. The paper contributes to urban theory and practice by providing new research on connections between arts and culture and community development. Findings are drawn from a 5-year study by The Urban Institute -- a national urban policy research organization in Washington, D.C. -- on developing indicators of arts and culture in community building in United States. Supported by The Rockefeller Foundation, the project includes field interviews, focus groups, and pilot projects in seven cities. The paper also offers literature review, conceptual frameworks, sample indicators, and a proposed Cultural Vitality Index for cities. For background information on the research project, please refer to:
http://www.urban. org/nnip/acip.html.

Creating and Destroying Social Capital

David Lazer & Nancy Katz

This paper examines the role that social capital plays in informal and formal processes of collaboration among students in a graduate public policy program. The paper examines the role of social capital in eight required first year courses, finding that a key intervening factor determining the impact of social capital was the overarching social organization of the students into "cohorts." Cohorts are the groups in which the students were oriented together, and took about half of their courses together withFor those courses that were "in cohort" the number of in-course friends was strongly related to the academic success of individuals; for those classes out of cohort, the number of in-course friends was not related to academic success. These data suggest that the cohort system allowed the build up of social capital within a group of students who were together across many classes. However, when the students were taken out of cohort, the value of any particular relationship, even if the pair of students were in the same section of the same course, was destroyed in the reshuffling process.

Roundtable on Network Visualization

Vladimir Batagelj, Ulrik Brandes, Steven R. Corman, Jeffrey C. Johnson, Stephen Kobourov, Lothar Krempel, Andrej Mrvar & Dorothea Wagner

Rather than a series of contributions on related subjects, this session features a single, joint presentation by all contributors. Our aim is to demonstrate the richness and power of network analysis, in particular when supported by visualization. We therefore present a multi-perspective analysis of a single data set (media coverage of the September 11 terrorist attacks), utilizing a broad range of visualization methods.

Evolution and Transitions in Networks

Drifting Smoke Rings: Longitudinal Social Network Analysis of Friendship Groups, Smoking and Drug-Taking

Michael Andrew Pearson

Social network analysis is applied to three time points of a longitudinal teenage friends and lifestyle study carried out at the Medical Research Centre, Glasgow. The study examines, among other things, how smoking and drug use in adolescence is associated with social position within peer group structures. One hundred and fifty nine secondary second grade students in one school named up to six best friends, allowing for the categorization of each adolescent as a group member, a group peripheral or a relative isolate. Building on previous work, which showed that the risk-taking behaviour of pupils on the periphery of peer groups reflected the behaviour within the groups, it is further demonstrated that transitions from non risk-taking behaviour to risk-taking behaviour occur predominantly at the peer group level of social position. The transitions of the pupils from time point one through to time point three are modelled in a Markovian way, so that the social position and risk-taking behaviour (or state) of a pupil at a certain time point is seen as being dependent on their state at the previous time point. It is found that there is a degree of predictability at the third time point in the expected number of pupils in the various sociometric states based on the transition probabilities derived at the second time point in one state school. The expected length of time spent by pupils in the various transitional states is also modelled making use of an embedded continuous-time Markov process. The results testify to the importance of risk-taking peer groups, both as a source of influence and selection of peripheral members, and to the need for differential targeting by social status when intervening or delivering health education programs.

Changes in Women's Personal Social Networks: Evidence from a Four-Year Longitudinal Study in West Africa

Gebre-Egziabher Kiros, John B. Caserline & Mark R. Montgomery

In this paper, we will examine women's social networks and the compositional changes over time in these networks. The data used for this analysis come from an ongoing longitudinal study on social diffusion and demographic dynamics conducted in six rural and peri-urban communities in southern Ghana. Six rounds of panel survey data collection were carried out in the period from October 1998 through November 2001, with social network data collected in every round. This analysis is restricted to networks defined by conversation about "modern contraception", the name-generator used in Rounds 2 and 5. In both rounds, women were asked to provide names of people with whom they have conversation about modern contraception in the last 12 months, and the interviewer was instructed to record all the names that the respondent volunteered. The sample for this analysis is 1,099 women interviewed in both Rounds 2 and 5. The average network size did not change significantly (1.5 and 1.8 in Round 2 and Round 5, respectively). In keeping with Snijders (2001) and Van Duijn et al. (1999), we use an actor--oriented network evolution model and a multilevel approach to analyse changes in network composition. The analysis will use SIENA (Snijders and Huisman, 2001), which is designed to ana-

lyse dynamic networks in which actors may depart or join. Every relationship is represented in an adjacency matrix, and the dependent variable is the change in relationships between network partners at times t1 (Round 2) and t2 (Round 5). The covariates to be incorporated in the analysis include: type of relationship (e.g., confidant, friend, relative, etc.), age, gender, marital status, ethnicity, level of schooling, community of residence, and whether they approve use of modern contraception.

Gender and Ethnicity in the Evolution of a Student Acquaintance Network

Mark Riddle & Robert Hanneman

Actors are likely to make homophilous choices for friends When faced with multiple dimensions of similarity from which to choose, how does an actor determine the salience of a given characteristic? Distinctiveness theory suggests that, faced with a heterogeneous group, people will give priority to the characteristic which places them in the smallest possible subgroup. The theory has been applied in the network literature to explain how minorities end up on the outskirts of centralized networks within firms. We use p* to test the theory in a classroom acquaintance network at three measurement times. We find little support for the principal claims of distinctiveness theory, but find that certain network effects (principally reciprocity and transitivity) interact with both gender and ethnicity over time.

Networks and Virtual Places

Office Workers Go Virtual

Arent Greve, Janet W. Salaff & Barry Wellman

Employees need to be able to communicate with formal and informal workmates and customers, and teleworkers must do so at a distance. In particular, when routines fail, bureaucrats draw on their informal relations to get the job done. Companies must take into account the formal as well as informal structure of the work community before implementing teleworking. By reshaping work structures, telework may hinder or ease access to others, thereby affecting how employees work. We contrast how bureaucratic and networked employees in the sales force of a large company exchange and coordinate information. We analyse lengthy interviews of 57 sales personnel, gathered 1994-7.

Where Home is the Workplace

Janet Salaff

Teleworking is a remote form of work that restructures the relationship between public and private spheres. Telework is part of this widespread industrial restructuring. We explore how telework incorporates and changes the factors of production, space, labour time, and capital. We draw on our research on teleworking in a large Canadian telecommunications company. Here we focus on the small business sales force, a subset of the firm's teleworking employees. We discuss the issues that the sales staff raise when they anticipate and strike the teleworking bargain, by looking at their experiences with and perceptions of this new form of employment. Since, few studies try to distinguish employers' and employees' perspectives, we address how people are engaged in this new form of labour largely by taking the employees' stance. The paper draws on interviews with 28 mobile office workers, within a larger study framework of 93 respondents.

Computer Networks as Social Networks: Computer Mediated Communication (CMC) Use and Structures

Comparison of Online Networks with the Social Network Perspective

Jae-Shin Lee, Helene Hembrooke, & Geri Gay

In this study, the social network concept is applied to computer-mediated communication networks. We distributed wireless laptops to students for the duration of one semester and recorded all online activities (including Web browsing, email exchange, and message postings to a bulletin board) on these laptops 24 hours/day, 7days/week in log files. Three networks were identified from the data: email exchange, bulletin board posting, and Web-browsing pattern networks. The email exchange network is believed to reflect the social network structure of students to the extent that the network shows who communicates with whom in what frequency. While the email network shows exchange of private messages, the bulletin board network illustrates students' exchange of messages in a public environment. The Web-browsing network was constructed based on students' Web browsing behaviour. In the Web-browsing network, students are connected to each other when they visited a common Web site. In this regard, the Web-browsing network is believed to represent an individual's unique online activity. The purpose of this study is to compare and contrast the three unique mediated networks and examine how the characteristics of each network are reflected on the network structure and property. Implications and issues of using electronically recorded longitudinal data will also be discussed.

The Smaller World Problem: Weak Ties and the New Media Ecology

Jonah Peretti

The Internet drastically increases the chance that weak social ties will actually be used to transfer information. I will describe a series of media experiments designed to dramatize this fact. I have created email forwards, web sites, and phone lines that are freely available to the public. I only tell my close friends about these projects but they are free to share them with others. In several cases, the projects have spread from my small social circle to tens of thousands, hundreds of thousands, and in one case millions of people. Although the weak ties on the Internet fuel this process, it is enhanced by mass media coverage in print and TV. Reporters discover the projects because a few weak social ties link them to my personal friends! My presentation will focus on two experiments. The first is an email exchange I had with Nike Corporation. The London Guardian estimated that this email forward spread to over 10 million people. I will describe the way that the email spread through the media ecology, from my close personal friends to producers at NBC's Today Show. The second example is the New York City Rejection Line. This project includes phone, web, and email distribution channels and has reached over 100,000 people. I will compare these two projects with particular emphasis on how technology affects the likelihood that individuals will use their weak social ties. Social Network theory has become increasingly important to my art and technology projects, so I am especially eager to receive feedback from the Sunbelt Social Networks community.

Post History: Visualizing Personal Email Networks Over Time

Fernanda Viegas & Judith Donath

Computer-mediated communication (CMC) offers new opportunities to visualize ego-networks, to identify ties that crosscut foci of activity, to aid in tie maintenance, and to identify the strength of network ties. Email, being a communication channel through which users have been interacting on an everyday basis for the past several years, presents a unique opportunity to observe one's social network as it changes in time. Post History is a visualization of email activity patterns over time; it is a tool intended to give users a much richer sense of their own email activities based on their evolving social networks. The visualization depicts a user's email activity on a day-to-day basis, Focussing on questions such as: When does a new tie appear in your email history? When does a tie fade out of your email history? How many messages are sent to you personally? How strong are the ties in your network (i.e. what is the frequency of contact and how personal are those contacts)? How many messages are CCed to you? Who CCs you on messages? Who do you CC? By addressing questions such as these, Post History creates a visual diary of past email usage while allowing users to observe some of the nuances in the patterns of their social networks.

Finding Clusters in Network Data and Generalized Blockmodels

Finding Clusters by Multiple Partial Iteration: Problems and Solutions

William Richards & Andrew Seary

We discuss a recent paper in Social Networks which suggests a novel method for extracting clusters from large, sparse networks by multiple partial iteration. We explain why the method works in terms of Normal eigenvectors, where the method may fail, and how to avoid this.

Generalized Blockmodelling of 2-Mode Networks

Vladimir Batagelj & Patrick Doreian

In 1991 we proposed the optimization approach to block-modeling problem of ordinary (1-mode) networks based on criterion functions compatible with structural and regular equivalence. In 1993 we extended this idea to other types of blocks - the generalized Blockmodelling. In 1996 we added to the approach the fitting to the pre-specified blockmodel. In the paper we present an extension of our generalized block-modeling approach to the analysis of 2-mode networks. The approach will be illustrated with several examples.

A Measure of Regularity

John P. Boyd

This paper introduces a measure of regularity Beta, which is partly based on Luce's beta model. Imagine a nonhomogeneous stochastic process where the observed number of 1s are placed sequentially back into a block of a matrix. Each placement can preferentially seek to enhance regularity, or to avoid it, according to whether Beta is greater or less than one, respectively. The parameter Beta can be estimated separately for rows and columns and for a single one-block or for all one-blocks in the matrix. Confidence intervals can be established numerically. A value of Beta less than one is consistent with a popularity bias operating within blocks, as indicated by the good fits to the negative binomial distribution on the block marginals. This method is applied to a number of classic social relations, finding that Beta is typically less than one, indicating an avoidance of regularity.

Community Structure in Social Networks

Michelle Girvan & M. E. J. Newman

Recent work has demonstrated that many social networks, as well as many networks of other types, have a number of statistical features in common. Researchers have concentrated particularly on three properties which many networks appear to exhibit: the small-world property, power-law degree distributions, and network transitivity. We highlight another property which is found in many networks, the property of community structure, in which network nodes are joined together in tightly-knit groups, between which there are only looser connections. We pro-pose a new method for detecting such communities, built around notions of edge centrality. Unlike traditional methods, like hierarchical clustering, which operate by identifying cores of communities, our approach works by detecting community boundaries. We test our method on computer generated and real-world graphs whose community structure is already known, and find that it identifies this known structure with high sensitivity and reliability. We apply our method to the social network formed by collaborations between a set of scientists and show that it detects significant and informative community divisions.

Computer Networks as Social Networks: Internet and Social Change

Netting the Globe: Comparing Internet Users and Uses Around the World

Wenhong Chen, Jeffrey Boase & Barry Wellman

As the Internet is being ushered in as the catalyst for broad social change, there is a need for research looking beyond the dichotomy of Internet access. Drawing on the National Geographic Survey 2000, our research examines how people around the world access the new technology, compare the diversity of Internet use, and explore the impacts of Internet on user's social network. We identify that there is a great diversity of Internet users, kinds of use, and impacts of Internet use from a global perspective:

1) In general, international users have a more elite profile than North American users, indicating higher socioeconomic barriers to Internet access and use outside of North America.

2) On one hand, the Internet empowers disadvantaged groups in that people who are elderly, less educated, unemployed, and newbies, are benefiting from the positive impacts of the Internet in that they have met new friends, like-minded people and all kinds of interesting people through the Internet, which gives them a sense of belonging to an online community. On the other hand, there is a clear Matthew effect: the greater the amount of Internet use, the stronger the positive effect on friends network and family ties.

3) While international users in general, and those in Eastern European, Asia Pacific and Oceania in particular are experiencing considerably more benefits of Internet effect on friends network than their North American counterparts, they are not as optimistic as US/Canadian users that the Internet has brought their

family closer. Our paper contributes to the knowledge of technology diffusion, the interaction between technology and societies, and especially, the ways that new technology impacts the social contacts of Internet users in different countries.

Fragmentation of Identity Through Structural Holes in Email Contacts

Danah Boyd, Jeff Potter, & Fernanda Viegas

Burt (1993) suggests that there are a number of advantages to maintaining structural holes in one's social networks, including controlling access to resources and maintaining personal privacy. By segregating social network members based on activity, it is relatively easy to maintain structural holes. As such, mixing contexts (i.e. converging groups at a party) is often disconcerting to people. When integrating the impact of digital social networks, such as those maintained in email, new issues in preserving structural holes emerge.

Group emails provide an easy mechanism for contacting one's social network en mass, yet this approach has implications on the structure of one's social network. One obvious potential effect is that, upon receiving a mass message, a tie might perceive that s/he is not valuable enough for a personalized message. While this is interesting, we are more fascinated by how the sender structures the recipient fields of group emails to control personal social networks.

We apply the theoretical ideas of structural holes to the digital forum, considering the role that email headers play in revealing and protecting one's social networks and the holes within. Referencing personal anecdotes, we discuss the varied ways in which a small number of people maintain their structural holes during their email interactions, particularly emphasizing the questions of why and how. For example, structural holes emerge when an individual forwards the same content to work colleagues and personal contacts under separate email messages. To analyse this behaviour, we visualize one individual's email archive, observing his digital social networks and structural holes. Using these different approaches, we hope to begin a more generalized discussion about the individual and societal impact of digitally maintaining structural holes. Such explicit maintenance raises questions concerning the relationship between fragmented individual identity and fragmented social networks.

Internet, Social Capital, and Information Seeking

Anabel Quan Haase, Barry Wellman, Jim Witte & Keith Hampton

How does the Internet affect social capital? Can the Internet counteract current trends of decline in civic engagement? The Internet with its communication and information seeking possibilities can be expected to facilitate interpersonal contact and participation in politics and organizations as well as to increase community commitment. The decline in civic engagement is mainly ascribed to younger generations' lessened engagement, the Internet seems especially useful in counteracting this trend because these are the generations that are most likely to use it. Our evidence comes from a 1998 survey of visitors to the National Geographic Society website, one of the first large-scale web surveys. We find that people's interaction online supplements their face-to-face and telephone communication, without increasing or decreasing it. It also supplements their participation in voluntary organizations and politics. And, those who use the web to communicate to friends and relatives online have positive feelings of community. Taken together, our evidence suggests that the Internet is becoming normalized as it is incorporated into the routine practices of everyday life.

Competition

The Market of Internet Search Engines (1993-2000): An Evolving Network Approach

Ivar Vermeulen

We analyse competitive dynamics in the market of Internet search engines, from its emergence in 1993 until 2000. This market has notable features: low entry barriers, next-to-perfect scale economies, few geographical constraints, no price competition, and impressive market growth. We measure simultaneous reference to pairs of search engines in documents on the Internet, for 137 individually operating search engines per quarter over a seven year period. The result is a series of valued graphs or networks, in which tie strength indicates the number of documents that mention both engines. We analyse this series of networks per quarter, and as an evolving network. The general pattern is a growing edge density, resulting in a growing connectedness, and the emergence of large components as predicted by random graph theory. The data demonstrate an emerging power law distribution of the degree sequence, as exhibited by other massive real world graphs like the Internet. This degree distribution can be explained by preferential attachment. We define a similarity measure on the valued graphs, and find an increasing dimensionality. Later years exhibit a core/periphery structure. Our results have intuitively plausible explanations. The growth of edge density is an obvious result of the search engine market's emergence. Three periods stand out: gradual growth until 1997 followed by turbulent growth that tapers out in the final years. The similarity measures can be interpreted as organizational niche overlap or competition. We distinguish two trends. First, a trend towards differentiation. New entrants avoid competition, and find a niche in a peripheral area of the market (e.g., by catering a specific language). Second, a trend towards uniformity. To win over the market's centre, some established search engines adapt, and consequently become similar.

Information Asymmetry, Risk and Interorganizational Ties in (Electronic) Markets

Otto Koppius

In a market, buyers are often faced with information asymmetry regarding the product they want to purchase. This information asymmetry arises because of missing information regarding factors that are relevant to the buyer's purchase decision, for instance product quality. As a consequence, the buyer makes assumptions about the missing information based on related factors, for instance supplier reputation, to mitigate he risky consequences of the missing information. The resulting buying behaviour can be one of three general types, based on whether this risk s dealt with through strategies of risk consolidation or risk spreading. In a risk consolidation strategy there will be a few strong ties (i.e. large transaction volume) with key suppliers, whereas in a risk spreading strategy there will be many weak ties (i.e. small transaction volume) with a large set of suppliers. The third general type is a hybrid of the two polar modes, where there is one strong tie with a key supplier in combination with several weak ties with other suppliers. In an electronic market, buyers face an increased information asymmetry because product description online is not as rich as seeing the physical product. I argue that instead of an overall increased reliance on sup-

plier reputation, increased information asymmetry will reinforce the buying strategy-in-use. Specifically, the network of buyers following a risk consolidation strategy will become even sparser and its ties stronger, whereas the network of buyers with a risk spreading strategy will become even denser and its ties weaker. For a hybrid strategy, a combination of these effects is expected to occur. These hypotheses are tested using a large dataset obtained at a Dutch flower auction before and after the introduction of a new electronic auctioning technology.

Who Gets Wall Street's Attention? Size and Density Dependence in the Effectiveness of Network-Based Market Signals

Michael Jensen

This study examines if network-based market signals affect the amount of attention firms receives from security analysts and how the ecological context of network-based market signals influences signal effectiveness. Specifically, it is argued that security analysts may take centrality in strategic alliance networks as a positive signal of firms' future prospects and that centrality therefore affects the amount of coverage firms receive from security analysts. However, it is also argued that the effectiveness of network-based market signals depends on their ecological context, defined here in terms of the density of the activity or attribute a given market signal is based upon, and that the strength of the relationship between centrality and coverage therefore is contingent upon the ecological context of the market signal. The study's main contribution is to introduce and document the importance of ecological context in understanding the consequences of network position in longitudinal network research. The importance of ecological context is tested empirically using extensive longitudinal data on strategic alliance activity and security analyst coverage in five high-tech industries from 1985 to 1997.

Social Capital in Context

Job Search and Social Support in the Underclass: What Kinds of Networks and Ties are Beneficial?

Jeanne S. Hurlbert, Valerie A. Haines, & John J. Beggs

In recent years, social scientists have renewed their focus on the problems and resources of the underclass. Among the prominent arguments emerging from this research has been the contention that the networks in which underclass residents are embedded provide social support but not assistance in such instrumental actions as job-finding. Extrapolating from research on the general population, researchers contend that this pattern owes to the fact residents of underclass areas are embedded in network structures that typically contain dense network sectors comprised of strong and homophilous ties; their networks lack wider-ranging network structures that are more likely to contain weak ties and diverse alters. However, researchers have not provided a complete, systematic test of this argument, in part because such a test requires data that tap strong ties, weak ties, and the resources that flow through those ties. To begin to fill that gap, we use data on residents of an underclass area and adjacent middle-class areas in a mid-sized Southern city to ask, empirically, whether the same kinds of network structures and ties affect access to social support and instrumental resources for individuals living in these very different environments. We find that the relationship between network structures and resources differs between the underclass and middle-class samples, in ways that are more complex than previous arguments have recognized. We conclude by exploring the implications for future studies of network structures and resources in the underclass.

In Search of the Master Witness in the Wedding Banquet: A Pilot Study of Social Capital in the Chinese Society

Nan Lin & Yang-chih Fu

Wedding banquet serves as an occasion to show case the social standing of the families in Chinese societies, particularly as reflected in the status of the Master Witness. The Master Witness, who presides over the ceremony and yet may be a total stranger to the families, is usually searched through direct or indirect ties by the parents of the groom or the bride. He, usually a male, symbolically represents the highest-reached status in the social hierarchy through the families' networks and, therefore, reflects the capability of the families' social capital. This paper presents preliminary findings from a pilot study recently conducted in Taiwan. We are interviewing around 50 couples that have been referred as newlyweds, by the respondents in a probability sample of Taiwan's Social Image Phone Survey. In the interview with these couples, we try to find out what kind of Master Witness the couple or the parents were looking for, who in the families initiated the search, whom he/she contacted, what their relationship was, and what (and how prestigious) this person's job was. In the case of indirect search, the use of secondary ties further displays how eagerly the parents mobilize their networks to demonstrate the families' status. We perceive such search processes as the manifestation of social capital in the Chinese institutional context. The data will reveal the extent of social capital to which the families can access, when they search for the Master Witness to anchor the wedding.

Fishing for Information: The Ethnographic Application of Social Network Analysis for Understanding the Social Construction of Race Among South African Fishers

Jamie Gates

The ethnographic application of social network analysis adds structure to our study of the socially constructed and historically situated nature of race. I accomplish this through an analysis of the relationships between coloured and white fishers in South Africa's handline fishing industry. In-depth interviews with 102 handline ski-boat skippers on the Western Cape coast serve as the core data for this analysis. An analysis of the skippers' perceived key information networks combined with an interpretation of the images and metaphors skippers use to describe themselves and others shows: 1) persons from disadvantaged groups are more likely to use diverse networks to gain access to the information and resources available through the networks of the advantaged; 2) persons from historically advantaged communities (i.e., white) were more likely to use densely knit, tightly bounded social networks to maintain benefits they already have; and 3) friendship networks prove more socially conservative than professional networks and are thus be more homogenous regardless of how ego classifies herself and others.

Scholarly Networks: Scientometric Study of Research Fields

Co-citation Analysis on Scholarly Personal Homepages on the World Wide Web

Saeko Nomura, Takeru Miki & Toru Ishida

For those who engage in intellectual occupations, such as researchers, constructing the good social networks is essential for their research activities. By utilizing the social networks, researchers can exchange important information, create new knowledge in concert, and sometimes establish new research area. The recent diffusion of various kinds of Internet applications promotes diversifying and expanding the social networks among researchers. In this situation, our work aims to clarify if the hyperlink structure of the WWW represents the scholarly networks and communities existing in the real world.

We obtained 10,455 personal web sites, that were managed by computer scientists engaging in several special fields, such as Artificial Intelligence, Software Engineering, Networking, and so on. The co-citation analysis was applied to these web sites, which were cited 14 times or more by other researchers. This selection criterion resulted in a pool of 102 computer scientists' web sites. In the co-citation analysis, principal component analysis with varimax rotation was used to extract factors. The result was mapped in two dimensions to grasp the structure of the scholarly communities existing on the WWW.

Three remarkable clusters that represented special fields in Computer Science were appeared: Artificial Intelligence, Programming Language, and Computer Architecture. We also found that the researchers who built bridges over the structural holes of these big clusters were the specialists of Cryptography and Information Security. In each cluster, researchers were not only highly co-cited, but also linked directly and densely each other. Even if we decreased citation frequency thresholds in order to increase the experimental subjects, we could confirm the same tendency. Therefore, this study clarified that the hyperlink structure of the WWW represents the social networks of researchers. The next step of this research is comparing the topology of Web-based scholarly communities to the literature-based (author co-citation analysis to the research outcomes such as conference and journal papers) communities.

Co-Author Networks and the Differentiation of Research Fields

Peter van den Besselaar

The cognitive differentiation and integration of a research field can be analysed in terms of scientiometric indicators like 'journal-journal citations' and 'joint cited references' (Van den Besselaar 2000). The first indicator can be used to delineate the various sub-fields, where the second shows the degree of the (remaining) shared body of knowledge. Using the field of 'science and technology studies' as an example, we found the high degree of cognitive differentiation reflected in the social structure of the research field (Van den Besselaar 2001). Researchers and research groups show a high degree of specialization in terms of the sub-fields. A author co-citation analysis collaborated these findings. Two questions remain to be answered. First, do the cognitive and the social differentiation co-evolve, or is one of the two leading the development? Second, to which extent do co-author relations function as weak ties between the sub-fields? Both questions will be addressed this paper, combining scientometric methods with social network analysis.

Socio-Cognitive Analysis and Pathfinder Network Scaling

Peter Mutschke

Based on graph theory, pathfinder network scaling is a structural-modeling technique that reduces a (huge) matrix of proximities to the most salient relationships by using a filtering criterion known as the triangular inequality condition. It has been extensively used in the study of knowledge representation, human and computer interaction, and, more recently, co-citation analysis. In this paper, pathfinder networks are used as an information filtering technique to represent large sets of structural relationships among authors in a scientific domain more effectively. The paper discusses the usefulness of this approach for the evaluation of relationships between cognitive and social structures of a research field (socio-cognitive analysis).

The Structure of Scientific Collaboration Networks

Mark Newman

Using data drawn from bibliographic databases we have constructed coauthorship networks for scientists in various scientific fields, including mathematics, biology, and physics. These networks are large social networks, some with millions of actors. We have measured a variety of statistical properties of these networks, some standard and some invented for the purpose. We find wide variation between the networks in different subjects, presumably revealing differences in social organization, as well as wide variation in the properties of individual actors within any one subject, as measured by indices such as degree centrality, between ness, clustering, network transitivity, and component structure. We also suggest a simple way of estimating the strength of collaborative ties and study the properties of the resulting valued network, as well as looking at the time evolution of collaboration networks, as revealed by the publication dates of papers.

Historical Network Analysis II

Networks of Persecution: A Suggestion on How to Analyse Inter-Organizational Networks in the Holocaust

Joerg Raab & Juergen Kloeckler

It has been shown in recent Holocaust research, that a multitude of actors directly and indirectly participated in the persecution of Jews. Especially the discussion on the economic persecution ("aryanization"/spoliation) has demonstrated, that besides the immediate persecution apparatus of the SS and Gestapo a multitude of state, societal and private actors were actively involved in the persecution, which had their main tasks and occupation in completely different areas, such as the tax offices, chambers of commerce, banks or professional associations. The reality of the Holocaust therefore was apparently characterized by complex interactions of a multitude of organizations. In the research project "Holocaust and Polycracy in Western Europe 1940 - 1944" it is attempted to determine the impact of the German occupation regimes in France, Belgium and the Netherlands from 1940-1940 on the persecution of Jews. These occupation regimes are understood and modelled as inter-organizational networks of German and indigenous actors. At the centre of the paper presented here is the attempt to collect relational

data from written texts, e.g. to combine content analysis with network analysis. The questions, problems and the proposed solutions are discussed by presenting results from a case study on the persecution of Jews converted to Christian congregations in the Netherlands in 1942/1943.

Petitions in the Social Context of Political Mobilization in the Revolution of 1848/49

Lothar Krempel & Carola Lipp

The paper analyzes the rise of the petition movement in a German town during the Revolution of 1848/49. Lists with names of 11 petitions allow to identify altogether 3942 signatures of 2184 activists in three phases of the petition movement. Additional data from a historical database describe over 120 activities (associations, committees, institutions and interest groups) with the memberships of 1986 individuals. These are used to identify a two-mode network (individuals by activities), and its overall structure based on overlapping memberships. How the social context contributes to the rise of the movement can be studied when mapping the petition activists on to this structure. This allows to compute individual levels of exposure for each of the 1284 individuals who signed a petition and who are simultaneously members of the overlapping activity structures. It is analysed in greater detail across different sections how this exposure to activists contributes to the diffusion of the petition movement for the three phases.

Catnets and Cohesion: The Problem of Coalition Formation in Non-democracies

Maryjane Osa

Collective action in non-democratic systems is more dependent on social networks than in democracies. In a democracy, political institutions provide the means for interest intermediation. In authoritarian regimes, the absence of institutionalized mechanisms for public choice means that social groups opposed to state policies operate outside the polity. The formation of oppositional networks, while difficult, is crucial for collective action in non-democracies (Osa and Corduneanu-Huci 2001). Moreover, coordination and coalition-building among oppositional groups are also constrained by the illiberal state. This paper examines the conditions under which oppositional networks produce coalitions in a non-democratic context. What characteristics of networks facilitate coalition-building? Network data are analysed for two waves of collective action in Communist Poland: 1966 - 1970 and 1976 to 1980. A series of sociograms show how opposition networks change over time; the analysis compares network structures in the first period, in which no coalition was achieved, with the network structures in the second period, which produced the broad-based Solidarity movement. The emergence of numerous peak organizations and new organizational categories are associated with successful coalition-building in T2.

Formal and Informal Intraorganizational Networks

Formal Structural Determinants of Informal Social Relationships in a High-Tech Service Organization

Qingxia Tong

This paper bridges the gap between the formal and informal organizational structural analysis by proposing a theoretical model of how various kinds of informal social relationships are differentially embedded in the formal organizational context. I argue that formal organizational structure exerts significant impacts on informal social relationships, mainly through the opportunities it opens for individuals to access various kinds of social resources. Specifically, there are three basic mechanisms through which formal structuring processes take place: creation of social similarity, creation of social proximity, and non-random allocation of resources among organizational members. Different types of social relationships would respond differently to the structural opportunities in formal organizations. I test the theoretical ideas with empirical data on the socialization and advice relationships in a high-tech service organization in China.

Friendship or Advice Network: A Choice Between Ambiguity and Uncertainty

Johanne Saint-Charles & Pierre Mongeau

Krackhardt and Brass (1994) suggested that contradictory findings regarding the role of friendship and advice networks in organizations can be explained by the type of uncertainty generated by the situations. To this assumption we can add the reflections of Weick (1995) about sense making in organizations which identifies two significant instances for sense making: situations of ambiguity and situations of uncertainty. Ambiguity occurs when actors are confronted with too many interpretations or information, causing a shock of confusion; uncertainty appears when there is a lack of information, causing a shock of ignorance. This leads to the hypothesis that people use friendship networks when situations are ambiguous while they reach for the advice network when there is uncertainty. We propose to verify this hypothesis through the use of a quasi-experimental method since the conduct of such a study in an organizational setting is constrained both by the complexity of organizations and by the heavy methodological requirements of network analysis. Indeed, it would be almost impossible to isolate situations of ambiguity and situations of uncertainty in organizations, which implies the identification and analysis of several organizational settings where either one of the situations is at least prevalent. This would lead to multiple networks analyses, which would be extremely costly both in human and financial resources. The use of a quasi-experimental method allows for the verification of the hypothesis at a much lower cost while ensuring the validity and the fidelity of the measurements obtained. Such a study should provide a more solid ground for the understanding of the respective roles of the friendship and advice networks. Moreover, insofar as uncertainty and ambiguity are at the heart of any change, this should lead to a new understanding of the dynamic of change in organization.

Resources and Identity in Social Networks: A Comparison of Strategic-Information Networks and Friendship Networks in a Multinational High Technology Company

Young-Choon Kim & Mooweon Rhee

This paper examines informal relationships of employees in a multinational high-tech company using the conceptual distinction of networks: resource-based and identity-based. This paper consists of two parts. First, we compare resource-based networks with identity-based networks in terms of size and composition. The findings show that resource-based net-works are larger and more heterogeneous than identity-based networks. Second, we examine the relationship between the network properties of informal relationships and organizational commitment in the two types of networks. We assess the effects of network

size, duration, communication media, and network composition on organizational commitment. Employees with large resource-based networks are highly committed to the company, while employees with identity-based networks of long duration are also highly committed. Face-to-face interfaces in identity-based networks enhance organizational commitment. Homogeneous composition of resource-based networks in terms of nationality promotes organizational commitment, but heterogeneous composition of identity-based networks opens the path to be more committed to that organization. These findings show that resource-based networks and identity-based networks have different characteristics and different consequences for commitment in a high-tech company. Finally, we discuss limitations and implications of this research.

Computer Networks as Social Networks: Computer Networks and Community

Neighbouring in Netville: How the Internet Supports Social Networks in a Wired Suburb

Keith N. Hampton

Critics argue that new technologies, such as the Internet, contribute to an incomplete lifestyle that withdraws people from in-person contact and disconnects us from our families, friends and communities. This research argues that CMC encourages the growth of social capital in the form of community involvement and in the expansion and strengthening of social networks. Based on survey and ethnographic data from Netville – one of the first residential developments in the world to be built from the ground up with a broadband high-speed local network – this study finds that Internet use is associated with increased social capital. Netville's local computer network reliably delivered network access at 10 Mbps, data transfer speeds 300 times faster than conventional dial-up Internet access and 10 times faster than what is available through most high-speed commercial cable modem and Digital Subscriber Line (DSL) services. Netville residents had access to services that included: high speed Internet access (including electronic mail and web surfing), a videophone, an online jukebox, online health services, local discussion forums and a series of online entertainment and educational applications. At the local level CMC in Netville encouraged public participation, community involvement, the growth of local social networks, and the spatial dispersion of local networks. In a situation where there was near ubiquitous access to CMC, Internet use encouraged visiting, surveillance, neighbour recognition, collective action and the maintenance of local social ties.

Networks of Practice: Applying Social Network Approaches to Examine Knowledge Exchange in Online Communities of Practice

Molly M. Wasko & Robin Teigland

Communities of practice (COPs) are being promoted within organizations as sources of competitive advantage and facilitators of organizational learning. However, individuals are increasingly participating in knowledge networks that exist online through computer-mediated communication. These networks exhibit similar characteristics to COPs and we refer to these electronic versions of COPs as "networks of prac-tice". Like COPs, networks of practice (NOPs) are emergent, informal groups that form around a shared practice in order to exchange knowledge, advice and ideas regarding common problems and issues. However, there are important differences between NOPs and COPs. In NOPs, the primary means of communication is through internet-based communication channels. NOP participants rarely have met each other face-to-face, nor do they share a common organizational or physical environment. Participants cross functional, geographical, and organizational boundaries, taking the time to provide valuable knowledge to each other in spite of the "weak" ties inherent in the networkFinally, knowledge exchanges are generally visible to the network as a whole, which contrasts with the more localized, tight-knit relationships in COPs. While COPs within organizations have received increasing attention, much less is known about the underlying dynamics of NOP participation. The goals of this research are to examine how NOPs sustain interactions and support know-ledge exchange between participants. We draw upon theories of core/periphery participation in COP research and adopt social network approaches to examine the structural dimensions of one extra-organizational NOP. The sample under study consists of 2,497 messages posted to the NOP by 597 unique knowledge workers during a two-month time period in the spring of 2001. We then integrate our findings to advance the development of theory in the area of networks of practice.

Network Sampling: Theory and Applications

Estimating the Prevalence of Male Clients of Prostitute Women in Vancouver with a Simple Capture-Recapture Method

John M. Roberts, Jr. & Devon D. Brewer

Data on the prevalence of prostitute women in the U.S. and reported number of sexual partnerships indicate that commercial partnerships may constitute the majority of hetero-sexual ties formed over periods of 5 years or longer (Brewer et al., 2000). Other evidence suggests that heterosexual men substantially under-report contact with prostitute women. In this paper, we use limited data on men arrested for patronizing prostitute women in 1986-1987 in Vancouver, Canada, and a simple capture-recapture method to estimate the prevalence of clients of prostitute women. We estimate that approximately 1-2% of adult males in the Vancouver metropolitan area patronized prostitutes during this two year period. This prevalence estimate is higher than those based on national probability sample survey data.

Social Network Sampling Design and Estimation

Steve Thompson

Methods for sampling in social networks include link-tracing procedures such as various forms of network and snowball sampling, random walks, and coupon-based respondent-driven sampling. Other methods involve the use of spatial sampling frames in combination with link-tracing. Some design issues and estimation methods for these sampling procedures will be discussed in this talk.

Conceptualizing Online Communities with Social Network Analysis

Stephen Chen

Based on a study of Singapore IRC channels done in 2000, this paper illustrates the utility of using social network analysis to study online communities. These findings are then validated with a separate measure. By comparing social network structures of 3 different IRC communities, a typology for conceptualizing

online communities as well as a sampling methodology for real-time online networks is proposed.

Collecting Social Network Information by National Wide Surveys, 13 Year Experience

Walter Bien

The German Youth Institute started 1987 a research project describing the structure of families in Germany. The used method was and is collecting the network of members of the family. Starting with egocentered networks of one reporter of each family we used several techniques and developments in survey collecting of networks. The paper shows the different methods, problems and used instruments and will discuss possibilities for future developments. The paper will also give some hints for constructing instruments collecting network relevant information in nation wide surveys.

Bayesian/Statistical Modeling

A Bayesian and Biased Nets Approach to Terrorist Network Prediction and Evaluation

Matthew J. Dombroski & Kathleen Carley

Network inference, error, and informant accuracy are explored using a Bayesian approach. Several sets of social network data are analysed in an effort to draw relationships, inferences, and insight between the input parameters of informant accuracy distributions and number of informants. The Bayesian approaches are being applied to terrorist network data in an effort to characterize a complete terrorist network using only limited network data. The goal is to determine how much security personnel must know about the terrorist network in order to make accurate predictions about the complete network. Different probability distributions of false positive and false negative rates are examined in the problem and results are evaluated using different numbers of informant reports. Biased nets research is applied to terrorist networks to find reciprocity biases, sibling biases, and double-role biases in terrorist networks. Using biased nets, more accurate priors can be inputted into the Bayesian methods to produce more accurate posteriors and thereby reduce errors in terrorist network structure prediction. Initial results indicate that the number of informant reports is a critical factor that reduces error significantly with increasing numbers of informants, regardless of their accuracy. More accurate priors also have a significant effect on reducing errors in the posterior. Several different rules are evaluated for modifying the prior network input into the Bayesian models.

Comparing Networks III: Replication and Relational Resemblance

John Skvoretz & Katherine Faust

This paper illustrates and extends methodology for comparison of social networks from different settingsWe use a rich and unique set of data, the Urban Communes Data, that were compiled by Benjamin Zablocki and made available by John Levi Martin. From this extensive data bank, we analyse eight relations (friendship, working together, loving, hateful, confiding, tension, closeness, and spending free time together) measured in five different communes. Our paper addresses three questions:

- What is the range of variability among networks that are nominally similar in the relation generating them?
- What is the extent of similarity among relations that are nominally different but measured in the same community?
- Is the variability within as set of networks related to exogenous variables describing the community, for example the number of levels of stratification or the ideological leaning of a commune?

We use methodology introduced in Faust and Skvoretz (forthcoming) and extended and illustrated in Skvoretz and Faust (forthcoming) for comparing the structures of networks from diverse settings, including networks that differ in size, type of relation, and even biological species of the units. This approach uses a p* model to quantify the structural properties of each network in a way that is comparable across different networks. It then employs parameter estimates from the models as the basis for assessing similarities in the structures of the networks and for representing these similarities spatially. This comparative methodology allows us to assess the extent to which network patterns are replicated across nominally similar relations, the extent to which there are resemblances among relations that are nominally different, and to evaluate how exogenous variables are related to variability among the networks.

A Bayesian Approach to Modeling Stochastic Blockstructures with Covariates

Christian Tallberg

A considerable amount of literature in social networks is concerned with the analysis of Blockmodelling. Wasserman and Anderson (1987) approached Blockmodelling within the framework of log-linear distributions. A Bayesian approach to posterior Blockmodelling has been presented by Snijders and Nowicki (1997), and Nowicki and Snijders (2001), where the posterior probability of block affiliation of actors is predicted. In this paper, the model outlined by Nowicki and Snijders (2001) is extended to include covariates on actor level. The estimation of block affiliation is considered by applying a multinormal probit model. Bayesian methods are presented here to estimate posterior distributions for model parameters and to compute posterior distributions for the block probabilities. Computer intensive methods are used. The key idea, presented by Albert and Chib (1993), is to introduce unknown independent latent variables drawn from truncated normal distributions. This technique, combined with the tool of Gibbs sampling, allows us to simulate from the posterior distributions of the model parameters. Suitable prior distributions are considered and computation of the posteriors is done by using the Gibbs sampler in which each draw is either Dirichlet, normal, truncated normal or Wishart.

Resistance is Futile: Assimilating Ego-Networks into a Single Structure

Ju-Sung Lee

Ego-networks, or ego-centric networks, have traditionally been studied in isolation. Information on where and how a single ego-network fits into the greater social structure is often unavailable, whether due to the absence of unique identifiers, such as full names or social security numbers (e.g. in HIV networks or networks of drug users), or a sampling strategy designed to obtain networks of disparate individuals (e.g. the 1985 GSS Social Network module). Computational approaches have allowed network researchers to probabilistically reconstruct complete networks from discrete ego-networks, allowing the analyses to, then, include aggregate level network measures. However, the current technology employs attribute information of egos and alters, and not the links between alters in a single ego-network. My research contributes to this method by introducing an algorithm

that connects ego-networks using both information sources: attributes and alter-to-alter ties. Furthermore, the gains from the inclusion of alter-to-alter ties are assessed as well as the expected error in the reformed network as a function of the size, density, network type (i.e. random vs. empirical), and the distributions of attributes and alter-to-alter ties. Preliminary results show that the error, hence the accuracy of the completed network, varies non-linearly and significantly with all of these parameters.

Books, Chapters, Articles

Abrahamson, John; James Dinniss. 2000. Ball lightning caused by oxidation of nanoparticle networks from normal lightning strikes on soil. *Nature* 403, 519 - 52.1

Observations of ball lightning have been reported for centuries, but the origin of this phenomenon remains an enigma. The 'average' ball lightning appears as a sphere with a diameter of 300 mm, a lifetime of about 10 s, and a luminosity similar to a 100-W lamp. It floats freely in the air, and ends either in an explosion, or by simply fading from view. It almost invariably occurs during stormy weather. Several energy sources have been proposed to explain the light, but none of these models has succeeded in explaining all of the observed characteristics. Here we report a model that potentially accounts for all of those properties, and which has some experimental support. When normal lightning strikes soil, chemical energy is stored in nanoparticles of Si, SiO or SiC, which are ejected into the air as a filamentary network. As the particles are slowly oxidized in air, the stored energy is released as heat and light. We investigated this basic process by exposing soil samples to a lightning-like discharge, which produced chain aggregates of nanoparticles: these particles oxidize at a rate appropriate for explaining the lifetime of ball lightning.

Adamic, Lada A; Huberman, Bernardo A. 2001. The Web's Hidden Order. *Communications of the ACM*, 44 (9), 55-59.

Wet side growth and popularity actually follow rule that can be explained mathematically and are useful for predicting the Web's future behavior. The past decade has seen the birth and explosive growth of the Web in terms of content and user population. Whereas in 1996 there were 61 million Internet users world-wide, at the end of 1998, more than 147 million people were Internet users worldwide, and able growth, the Web has popularized e-commerce, and result an increasing segment of the world's population conducts commercial transactions online.

Alberich, R; Miro-Julia, J; Rossello, F. 2002. *Marvel Universe looks almost like a real social network.* Spanish: Elsevier.

We investigate the structure of the Marvel Universe collaboration network, where two Marvel characters are considered linked if they jointly appear in the same Marvel comic book. We show that this network is clearly not a random network, and that it has most, but not all, characteristics of "real-life" collaboration network, such as movie actors or scientific collaboration networks. The study of this artificial universe that tries to look like a real one, helps to understand that there are underlying principle that make real-life networks have definite characteristics.

Banavar, Jayanth R; Amos Maritan; Andrea Rinaldo. 1999. *Nature* 399, 130 - 132.

Many biological processes, from cellular metabolism to population dynamics, are characterized by allometric scaling (power-law) relationships between size and rate. An outstanding question is whether typical allometric scaling relationships—the power-law dependence of a biological rate on body mass—can be understood by considering the general features of branching networks serving a particular

volume. Distributed networks in nature stem from the need for effective connectivity, and occur both in biological systems such as cardiovascular and respiratory networks and plant vascular and root systems,,, and in inanimate systems such as the drainage network of river basins. Here we derive a general relationship between size and flow rates in arbitrary networks with local connectivity. Our theory accounts in a general way for the quarter-power allometric scaling of living organisms, recently derived under specific assumptions for particular network geometries. It also predicts scaling relations applicable to all efficient transportation networks, which we verify from observational data on the river drainage basins. Allometric scaling is therefore shown to originate from the general features of networks irrespective of dynamical or geometric assumptions.

Barabasi, Albert-Laszlo; Albert, Reka. 1999. Emergence of scaling in random networks. *Science*, 286, 509-512. http://www.nd.edu/~networks/Papers/science.pdf

Systems as diverse as genetic networks or the world wide web are best described as networks with complex topology. A common property of many large networks is that the vertex connectivities follow a scale-free power-law distribution. This feature is found to be a consequence of the two generic mechanisms that networks expand continuously by the addition of new vertices, and new vertices attach preferentially to already well connected sites. A model based on these two ingredients reproduces the observed stationary scale-free distributions, indicating that the development of large networks is governed by robust self-organizing phenomena that go beyond the particulars of the individual systems.

Barabási, Albert-Lásló. 2002. *Linked: The New Science of Networks*. Perseus Publishing.
The past few years have seen an explosion of interest in so-called complex networks. In the physical sciences we are familiar with regular lattice networks of atoms, in which the local environment of each atom is identical. Such systems have traditionally been used to model the cooperative behaviour of interacting lattice systems — such as phase transitions — in which interactions are mediated by the underlying lattice.

However, recent work by Steven Strogatz and Duncan Watts on small worlds and by Albert-Lásló Barabási and Réka Albert on scale-free networks has suddenly enlarged our notions of what actually constitutes a network. For example, in social settings it is clear that the acquaintance network formed by a collection of individuals is strongly heterogeneous. Some people are essentially reclusive and have few links to the outside world, whereas others are linked to a wide circle of friends. It would be inappropriate to describe such friendship networks as a regular lattice; something more akin to an airline route map, with a large number of poorly linked nodes and a few well-linked major 'hubs', seems more relevant. In fact, many man-made and natural networks, with the Internet and the web being two of the most obvious examples of the former type, appear to have just this kind of interconnection. Cooperative behaviour in such networks, as in the transmission of viruses among people or computers, is drastically different from that in lattices, and has many important epidemiological implications.

In Linked, Barabási presents an entertaining introduction to this vital field at a level that is generally accessible to the layperson interested in modern science. Barabási has made seminal contributions to the characterization of complex networks and has become an authoritative and forceful spokesman for the field. His enthusiasm is apparent throughout the narrative, a feature that makes for good reading. The book unravels many of the intriguing features of complex networks and will greatly enlarge a layperson's conceptions of what networks are all about.

The early sections of the book are interesting and informative. They include, for example, the stories about the original work on the six degrees of separation (the idea that just five links can connect any two people), the many amusing tales about the legendary mathematician Paul Erdos and his contributions to random graph theory, and the advances on small-world networks by Strogatz and Watts. Many applications are introduced with compelling examples, such as the AIDS epidemic to describe virus propagation through complex networks, or the early development of the Internet. It is very easy to be drawn in; many sections of the book have the feel of entertaining storytelling during conversations at a pavement café.

The middle chapters — called links — present a personalized account of recent advances in the field, including the many substantial contributions made by the author and his research group. Among these

are the original formulation of the scale-free network and its myriad of applications, the 'fitness' model, the behaviour of networks under attack, the spread of viruses and the role of complex networks in living organisms. Again, much of the work is presented in a highly digestible form (the numbered subsections help considerably here) and will pique the interest of many readers. Reviewed by Sidney Redner, 2002 . *Nature* 418, 127-128.

Boase, Jeffrey: Wellman, Barry. 2001. A Plague of Viruses: Biological, Computer, and Marketing. *Current Sociology*, Current Sociology 49 (6).

We analyze the transfer of biological, computer and word of mouth marketing viruses. Despite differences between these three types of viruses, network structure affects their spread in similar ways. We distinguish between two types of networks—densely knit and ramified—and show that biological, computer and marketing viruses all behave in similar ways depending on the type of network. densely knit networks promote the quick dissemination of a virus, and increase the odds that many of the members will become infected, Ramified networks allow a virus to disperse widely, jumping between different milieus. In the end, the spread of viruses in the real world involves a combination of both densely knit and ramified networks, which we call “glocalization”.

Boudourides, Moses A. 2001. Networks, Fluids, Chaos. Unpublished manuscript. (contribution to the International Conference *Spacing and Timing Rethinking Globalization & Standardization* Palermo, Italy).

Our aim in this essay is to talk about three forms of social spatiality: networks, fluids and chaos. These forms are being inscribed into various theories and are being mobilized into multiple translations (metaphors) as states in which things exit or as processes through which things are transformed. Although these specialities are sometimes recognized in their static instantiations (as frozen topologies, static structure or equilibrium patterns), the full extend of their existence does include time-duree (as the signature of recurrent agency permeating in their modalities). Dynamic or evolving networks, non-stationary flows and irreversible chaotic processes are all examples of time dependent processes structuring these complex spatialities.

Buchanan, Mark. 2002. *Nexus: Small Worlds and the Groundbreaking Science of Networks/Small World: Uncovering Nature's Hidden Network*s. W. W. Norton/Weidenfeld & Nicolson.

Nexus is very similar to *Linked* (Barabási, 2002). Written by Mark Buchanan, a science writer and physics doctorate, it gives a cogent and engaging description of recent developments in complex networks. There is much overlap with *Linked*, in both content and style. But Barabási's book is more focused and follows many of his own very important contributions, whereas Buchanan's provides a slightly broader perspective but sometimes strays from the topic of networks. Reviewed by Sidney Redner, 2002. *Nature* 418, 127-128.

Cancho, Ramon Ferrer; **Ricard V Solé.** 2001. The small world of human language. *Proc. R. Soc. Lond.* 268, 2261-2265.

Words in human language interact in sentences in non-random ways, and allow humans to construct an astronomic variety of sentences from a limited number of discrete units. This construction process is extremely fast and robust. The co-occurrence of words in sentences reflects language organization in a subtle manner that can be described in terms of a graph of word interactions. Here, we show that such graphs display two important features recently found in a disparate number of complex systems. (i) The so called small-world effect. In particular, the average distance between two words, d (i.e. the average minimum number of links to be crossed from an arbitrary word to another), is shown to be $d \circ 2 \hat{} 3$, even though the human brain can store many thousands. (ii) A scale-free distribution of degrees. The known pronounced effects of disconnecting the most connected vertices in such networks can be identified in some language disorders. These observations indicate some unexpected features of language organization that might reflect the evolutionary and social history of lexicons and the origins of their flexibility and combinatorial nature.

Carpenter, Mason A; Westphal, James D. 2001. The strategic context of external network ties: Examining the impact of director appointments on board involvement in strategic decision making. *Academy of Management Journal*, 44 (4): 639-660.

This study examines how external network ties determine a board's ability to contribute to the strategic decision making process. Although the simple number of director appointments to other boards does not affect board monitoring or advice on strategy, appointments that can provide directors with relevant strategic knowledge and perspective do predict such involvement. In effect, the strategic context of social network ties, not simply the number of ties, is an important influence on corporate governance.

Cate, Rodney M; Levin, Lauren A.; Richmond, Lucinda S. 2002. Premarital relationship stability : A review of recent research. *Journal of Social and Personal Relationships*, 19(02).

This article is a review of the theory and recent literature on premarital relationship stability. First, current theories and models that have been used to explain the development of premarital relationships are discussed. Second, research since 1990 that focuses on the individual, dyadic, and social network factors that predict premarital relationship stability is presented. Third, we integrate the findings of the review into a commitment model and make some brief observations about theoretical, conceptual, and methodological issues that must be addressed to further understand the development of premarital relationships.

Chase, Ivan D; Tovey, Craig; Spangler-Martin, Debra; Manfredonia, Michael. 2002. Individual differences versus social dynamics in the formation of anima dominance hierarchies. *Publication of the Natural Academy of Sciences*, 99 (8): 5744-5749.

Linear hierarchies, the classic pecking-order structures are formed readily in both nature and the laboratory in a great range of species including humans. However, the probability of getting linear structures by chance alone is quite low. In this paper, we investigate the two hypotheses that are proposed most often to explain linear hierarchies: they are predetermined by differences in the attributes of animals, or they are self-organizing. We evaluate these hypotheses using cichlid fist as model animals, and although differences in attributes play a significant part, we find that social interaction is necessary for high proportions of groups with linear hierarchies. Our results suggest that dominance hierarchy formation is much richer and more complex phenomenon that previously thought, and we explore than implications of these results for evolutionary biology, the social sciences, and the use of animal models in understanding human social organization.

Dayan, Joelle; Doyle, Anna-Beth; Markiewicz, Dorothy. *2001*. Social support networks and self-esteem of idiocentric and allocentric children and adolescents. *Journal of Social and Personal Relationships*, 18(6), 767-784.

People who have an idiocentric value orientation tend to emphasize their own goals and needs over those of the groups to which they belong, and to be independent and self-reliant. Allocentric individuals tend to be cooperative, interdependent, and to have a stronger need to affiliate with others than idiocentric. A goal of this study was to investigate how children's social relationships and self-esteem vary as a function of their allocentrism. Participants were 419 children between 9 and 18 years of age from a variety of ethnic backgrounds (French Canadian/ Quebecois, Greek, Arabic, and Caribbean). As expected, allocentric children reported sources of intimacy and companionships, for example from best friends, mothers, and relatives. Also, the self-esteem of idiocentric children, but not of allocentric children, was predicted by social support from their best friend. Implications are that idiocentric and allocentric individuals seek out different members of their social networks to satisfy various needs, and to strengthen their self-esteem

Eckmann, Jean-Pierre; Moses, Elisha. 2001. *Curvature of Co-links uncovers hidden thematic layers in the world wide web*. Proc. Natl. Acad. Sci. USA published 23 April 2002,.

Beyond the information stored in pages of the World Wide Web, novel types of "meta-information" are created when they connect to each other. The information is a collective effect of independent users writing and linking pages, hidden from the casual user. Accessing it and understanding the inter-relation of connectivity and content in the WWW is a challenging problem (1-4). We demonstrate here how thematic relationships can be located precisely by looking only at the graph of hyperlinks, gleaning content and context from the Web without having to read what is in the pages. We begin by noting that reciprocal link (co-links) between pages signal a mutual recognition of authors, and then focus on triangles containing such links, since triangles indicate a transitive relation. The importance of triangles indicates a transitive relation. The importance of triangles is quantified by the clustering coefficient (5) which we interpret as a curvature. This defines a Web-landscape whose connected regions of high curvature characterize a common topic. We show experimentally that reciprocity and curvature, when combined accurately capture this meta-information for a wide variety of topics. As an example of future directions we analyze the neural network of C. elegans, using the same methods

Farrell, Michael P. 2001. *Collaborative Circles*. Chicago: The University of Chicago Press.

In a unique study that will become a rich source of ideas for professionals and anyone interested in fostering creative work in the arts of sciences, Michael P. Farrell looks at the group dynamics in six collaborative circles: the French Impressionists; Sigmund Freud and his friends; C. S. Lewis, J. R. R. Tolkien, and the Inklings; social reformers Elizabeth Candy Stanton, Susan B. Anthony, and the "Ultra s" in the women's movement; the Fugitive poets; and their friends. Farrell presents vivid narrative accounts of the development of each circle and the roles each member played. He considers how circles from; how the leadership, group rituals, and interpersonal relations change as circles develop; how the dynamics of circles stimulate creative work; and why some circles flourish while others flounder

Goh, K.-I; Kahng, B. ; Kim, **D.** 2001. Spectra and eigenvectors of scale-free networks. *Phys. Rev. E*. 64. 051903.

We study the spectra and eigenvectors of the adjacency matrices of scale-free networks when bidirectional interaction is allowed, so that the adjacency matrix is real and symmetric. The spectral density shows an exponential decay around the center, followed by power-law long tails at both spectrum edges. The largest eigenvalue λ_1 depends on system size N as $\lambda_1 \sim N^{1/4}$ for large N, and the corresponding eigenfunction is strongly localized at the hub, the vertex with largest degree. The component of the normalized eigenfunction at the hub is of order unity. We also find that the mass gap scales as $N^{-0.68}$.

Hardin, Russell. 2002. *Trust and Trustworthiness*. New York: Russell Sage Foundation.

What does it mean to "trust"? What makes us feel secure enough to place our confidence—even at times out welfare—in the hands of other people? Is it possible to "trust" an institution? What exactly do people mean when they claim to "distrust" their governments? As difficult as it may be to define, trust is essential to the formation and maintenance of a civil society. In *Trust and Trustworthiness* political scientist Russell Hardin addresses the standard theories of trust and articulates his own new and compelling idea; that much of watch we call trust can be best described as "encapsulated interests".

Hastie, Reid; Dawes, Robyn M. 2001. *Rational Choice in an uncertain world*. Thousand Oaks, CA: Sage.

An understanding of the principles of rational decision making can help students improve the quality of their lives. Thus, the material in *Rational Choice in an Uncertain World* is not only of scholarly interest, but practical as well. Created specifically for courses on judgment and decision-making, this book makes research readily accessible to both undergraduate and graduate students.

Johnson, J.C; Weller, S.C; Brewer, B.D. 2002. Systematic Data Collection and Analysis. *Field Methods*, *14* (1): 3-5.

Although this special issue highlights systematic methods of data collection and analysis, the true contribution of the articles in this volume concerns the value of such methods in facilitating valid comparisons among and between groups, individuals, sub-populations, and so forth. As the quote by Campbell implied, theoretical understanding is gained through comparisons of one form or another as in, for example, classic experimental control/ treatment designs despite this, any methods, used by contemporary social scientists vary dramatically in their ability to allow for valid comparisons among units of interest, comparisons that are critically important for the development and testing of theory. The series of articles in this issue represents one of three special issues based on papers presented at a symposium in honor of A. Kimball Romney. Each article in this special issue reflects Romney's important contribution to the development and application of systematic methods of data collection and analysis. The first four provide examples of comparative research in which the use of systematic methods is critical for making valid theoretical assessments.

Keeble, Leigh; Loader, Brain, D. *2001. Community Informatics Shaping computer-mediated social relations*. New York, USA: Routledge.

This book is the outcome of an international conference which was organized by the Community Informatics Research and Applications Unit (CIRA) based at the University of Teesside, UK, in April 2000. It was an event which brought together a number of leading practitioners, academics and community activists who share a common desire to understand and use the potentially transforming equalities of information and communications technologies (ICTs) for developing stronger community relationship. The vision and energy of community informatics practitioners is now beginning to provide us with some exciting examples of innovative applications and a growing source of lay experience and academic research outputs upon which to gain a clearer understanding of these developments and their potential consequences for community relations. The chapters in this book provide a wide coverage of the lessons which are beginning to be learnt from many of these social experiments, They sometimes identify a significant divergence between the rhetoric of enthusiasts and the actual experience on the ground. Moreover, we cannot even be sure that they do not represent a transitory set of well-intentioned rejects that the torches of the early community-network pioneers will not be extinguished by greater social and economic forces. Yet they may also give us an insight into the potential of people to shape the new media in ways which are emancipatory, creative, educational and socially supportive. As such they could provide some valuable early lessons to inform future policy choices.

Kim, Beom Jun; Chang No Yoon; Seung Kee Han; Hawoong Jeong. Path-fnding strategies in scale-free networks. http://www.tp.umu.se/~kim/Network/network.pdf

We numerically investigate the scale-free network model by Barabási and Albert (Science, 1999, 286, 509) through the use of various path finding strategies. In real networks, the global network information is not accessible to each vertex, and the actual path connecting two vertices can sometimes be much longer than the shortest one. A generalized diameter depending on the actual path finding strategy is introduced, and a simple strategy, which utilizes only the local information on the connectivity, is suggested and shown to yield the small-world behavior: the diameter D of the network increases logarithmically with the network size N, the same as found with the global strategy. If paths are sought at random, $D \sim N^{0.5}$ is found.

Kleinberg, Jon M. 2000. Navigation in a small world. *Nature* 406: 845.

The small-world phenomenon — the principle that most of us are linked by short chains of acquaintances — was first investigated as a question in sociology and is a feature of a range of networks arising in nature and technology. Experimental study of the phenomenon revealed that it has two fundamental components: first, such short chains are ubiquitous, and second, individuals operating with purely local information are very adept at finding these chains. The first issue has been analysed, and here I investigate the second by modelling how individuals can find short chains in a large social network.

Lawler, Edward J. 2001. An affect theory of Social exchange. *American Journal of Sociology*, 107 (2): 321-52.

This article develops a theory that explains how and when emotions, produced by social exchange, generate stronger or weaker ties to relations, groups, or networks. It is argued that social exchange produces positive or negative global feelings, which are internally rewarding or punishing. The theory indicates that social units (relations, groups, networks) are perceived as a source of these feelings, contingent on the degree of jointness in the exchange task. The jointness of the task is greatest if (1) actors find it difficult to distinguish their individual effects on or contributions to solving the exchange task (nonseparability) and (2) actors perceive a shared responsibility for success or failure at the exchange task. The theory explicates the effects of different exchange structures on these conditions and, in turn, on cohesion and solidarity. Implications are developed for network-to-group transformations.

Lazega, Emmanuel. 2001. *The collegial Phenomenon: The Social Mechanisms of Cooperation among Peers in a Corporate Law Partnership*. Oxford, UK: Oxford University Press.

The author examines cooperation (and competition) among partners in a US corporate law firm and provides a grounded theory of collective action among rival peers, or collegiality. He employs a broadly-conceived structural approach involving social network analysis and combining it with ethnographi es of task forces, and analysis of management and internal politics of the firm. The book recommends itself and not just become he published one of his scientific articles on the subject in the BMS: Emmanuel Lazega and Stephane Vari, "Acteurs, cibles et leviers: Analyse factorielle des relations de contro le indirect dans une firme americaine d'avocats d'affairs", BMS, December 1992, n 37: 41-51

Levitt, Peggy. 2001. The *Transnational Villagers*. Berkeley, California: University of California Press.

This book is organized into three parts. I begin, in the following chapter, with a historical overview of the Dominican Republic, its migration patterns, and the Latino community in Boston. In Chapter 2, I introduce the concept of social remittances. Part Two describes how migration transforms daily life in ways that encourage transnational-community continuity. Chapter 3 examines changes in work, family, and school life. Chapter 4 describes the value transformations underlying these changes. Part Three analyzes the political, religious, and community organizational forms that create and are created by these relationships and their consequences for social and political life. I examine the Partido revolucionar io Dominicano, the Catholic Church, and the Miraflores Development Committee. The conclusion includes a summary of my findings and a discussion of their implications for our thinking about incorporation, participation, and citizenship.

Liljeros, Fredrik; Edling, Christofer R.; Nunes Amaral, Luís A.; Stanley, H. Eugene; Åberg, Yvonne. 2001. The web of human sexual contacts. *Nature* 411, 907-908.

Unlike clearly defined 'real-world' networks1, social networks tend to be subjective to some extent2,3 because the perception of what constitutes a social link may differ between individuals. One unambiguous type of connection, however, is sexual contact, and here we analyse the sexual behaviour of a random sample of individuals to reveal the mathematical features of a sexual-contact network. We find that the cumulative distribution of the number of different sexual partners in one year decays as a scale-free power law that has a similar exponent for males and females. The scale-free nature of the web of human sexual contacts indicates that strategic safe-sex campaigns are likely to be the most efficient way to prevent the spread of sexually transmitted diseases.

Our results may have epidemiological implications, as epidemics arise and propagate much faster in scale-free networks than in single-scale networks6,13. Also, the measures adopted to contain or stop the propagation of diseases in a network need to be radically different for scale-free networks. Single-scale networks are not susceptible to attack at even the most connected nodes, whereas scale-free networks are resilient to random failure but are highly susceptible to destruction of the best-connected nodes14. The possibility that the web of sexual contacts has a scale-free structure indicates that strategic targeting of safe-sex education campaigns to those individuals with a large number of partners may significantly

reduce the propagation of sexually transmitted diseases.

Lomi, Alessandro; Larsen, Erik R. 2001. *Dynamics of Organizations*, Cambridge, MA: MIT Press.

AN organization is more than the summer of its parts, and the individual components that function as a complex social system can be understood only by analyzing their collective behavior. This book shows how state-of- art simulation methods including genetic algorithms, neural networks and cellular automata can be brought to bear on central problems of organizational theory related to the emergence, permanence, and dissolution of hierarchical macrostructures. The emphasis is on the application of a new generation of equation and agent-based computational models that can help students of organizations to reformulate their basic research questions starting from assumptions about how to link—rather than separate—different levels of organizational analysis.

Lovelace, Kay; Shapiro, Debra L; Weingart, Laurie R. 2001. Maximizing cross-functional new product teams' innovativeness and constraint adherence: A conflict communications perspective. *Academy of Management Journal*, 44 (4): 779-793.

Increasing competition resulting from the global and technological nature of markets has heightened the need for businesses to rely on cross-functional new product teams to produce innovations in a timely manner; yet functionally diverse teams' inevitable disagreements often appear to prevent this. In a study of 43 such teams, it was found that the effect of task disagreement on team outcomes depended on how free members felt to express task-related doubts and how collaboratively or contentiously these doubts were expressed. Implications for managing the journey from disagreement to agreement in cross-functional new product teams are discussed.

Madhavan, Sangeetha. 2001. Female Relationships and Demographic Outcomes in Sub-Saharan Africa. *Sociological Forum*, 16 (3).

This paper examines possible ways in which female relationships can affect demographic outcomes within the context of an extended family structure is sub-Saharan Africa. The level of collaboration and competition that exists among co resident women is likely to have an impact on fertility through changes in birth spacing and stopping behavior. In addition, the extent of collaboration could be a contributing factor in the survival chances of infants and young children. Given the multitude of ethnic groups found on the African continent, the paper also addresses the independent and interactive roles of culture. The paper ends with a discussion of theoretical and methodological implications for demographic research and suggestions for further study.

Matzat, Uwe. 2001. *Social Networks and Cooperation in Electronic communities: A theoretical-empirical study on academic communication and internet discussion group*s. Unpublished Thesis.

This book would like to show that it is useful to link research about effects of the Internet and about interaction in electronic groups to general sociological theories about human behavior. Such a link makes it possible to explain under which social conditions an Internet tool is accepted or rejected by the user, how it is used, and what outcomes of the user of a tool of the Internet are to be expected. The strategy used here is to use a very simple model of goal oriented human behavior to explain the relationship between different phenomena at the macro-level.

McMahon, S.M. et al. 2001. Ecology and Social Network Analysis. *Science*, 293:1604.

The authors discuss ecology and social network analysis. For the past 30 years, a subdiscipline of the social sciences knows as “social network analysis” has developed structural models to analyze human interactions. In social network analysis, discrete mathematics and statistics are combined with the emerging epistemology of complex systems to explore processes and phenomena as diverse as the diffusion of information through an organization, the adoption of innovations on society, and the spread of infectious disease in a population. Researchers working on social network analysis draw upon many

disciplines: sociology, anthropology, psychology, geography, mathematics, statistics and computer science.

McPherson, Miller; Smith-Lovin, Lynn; Cook, James M. *2001*. Birds of a Feather: Homophily in Social Networks. *Annual Review of Sociology*, 27, 415-44.

Similarity breeds connection. This principle--the homophily principle--structures network ties of every type, including marriage, friendship, work, advice, support, information transfer, exchange, comembership, and other types of relationship. The result is that people's personal networks are homogeneous with regard to many sociodemographic, behavioral, and intrapersonal characteristics. Homophily limits people's social worlds in a way that has powerful implications for the information they receive, the attitudes they form, and the interactions they experience. Homophily in race and ethnicity creates the strongest divides in our personal environments, with age, religion, education, occupation, and gender following in roughly that order. Geographic propinquity, families, organizations, and isomorphic positions in social systems all create contexts in which homophilous relations form. Ties between nonsimilar individuals also dissolve at a higher rate, which sets the stage for the formation of niches (localized positions) within social space. We argue for more research on: (a) the basic ecological processes that link organizations, associations, cultural communities, social movements, and many other social forms; (b) the impact of multiplex ties on the patterns of homophily; and ©) the dynamics of network change over time through which networks and other social entities co-evolve.

Menczer, Filippo. 2002. Growing and navigating the small world Web by local content. *Proceedings of the National Academy of Science, USA*, Vol. 99, Issue 22, 14014-14019.

Can we model the scale-free distribution of Web hypertext degree under realistic assumptions about the behavior of page authors? Can a Web crawler efficiently locate an unknown relevant page? These questions are receiving much attention due to their potential impact for understanding the structure of the Web and for building better search engines. Here I investigate the connection between the linkage and content topology of Web pages. The relationship between a text-induced distance metric and a link-based neighborhood probability distribution displays a phase transition between a region where linkage is not determined by content and one where linkage decays according to a power law. This relationship is used to propose a Web growth model that is shown to accurately predict the distribution of Web page degree, based on textual content and assuming only local knowledge of degree for existing pages. A qualitatively similar phase transition is found between linkage and semantic distance, with an exponential decay tail. Both relationships suggest that efficient paths can be discovered by decentralized Web navigation algorithms based on textual and/or categorical cues.

Mesch, Gustavo S; Manor, Orit. 2001. Ethnic Differences in Urban Neighbor Relations in Israel. *Urban Studies*, 38 (11): 1943-1952.

This study considers the role of ethnic differences in the relevance of the local community as a network of social relations that provide companionship, friendship and social support. Data for this study were collected from a representative sample of the population in the Haifa metropolitan area, the third-largest metropolitan area in Israel. It was found that measures of investment in the neighborhood such as homeownership and stage in the life-cycle were not related to the number of locally based instrumental ties. However, nationality had a negative effect. Israeli Jews reported fewer locally based instrumental ties than the Arab Israelis. The findings provide partial support for compression theory. Israeli Arabs reported a higher number of locally based instrumental social ties than Israeli Jews. Apparently their higher levels of residential segregation compressed their social relationships to the local neighborhood more than was the case for Israeli Jews. Implications of the findings for other theoretical frameworks are discussed.

Miller, Alison L; Notaro, Paul C.: Zimmerman, Marc A. 2002. Stability and change in internal working models of friendship : Associations with multiple domains of urban adolescent functioning. *Journal of Social and Personal Relationships*, 19 (02).

We examined the role of stability and change in low-achieving urban African American adolescents' internal working models of their close friendships across multiple domains of functioning. We compared three groups of youth defined by their attachment orientation based on two ratings one year apart: (i) stable-secure (secure both years); (ii) stable-insecure (insecure both years); and (iii) changing orientation. We assessed psychological well-being, participation in problem behaviors, negative peer influences, school attitudes, and sexual behavior, hypothesizing that adolescents reporting stable secure internal working models of friendship would show the highest levels of functioning across all domains, followed by adolescents reporting instability in their friendships and adolescents reporting stable insecure orientations. Internal working models of friendship were assessed using a modified version of Hazan and Shaver's (1987) Adult Attachment Classifications. Across all domains, adolescents with stable secure orientations functioned better than those with stable insecure internal working models (e.g., less problem behavior and more positive school attitudes). The change group either resembled the stable-insecure group or fell in between the two stable groups. Analyses comparing outcomes based on the direction of change in attachment orientation (i.e., change to secure versus change to insecure) revealed main effects for problem behaviors and sex by change direction interaction effects for sexual behavior. These results suggest that low-achieving adolescents' attachment orientations change over time and are associated with deleterious outcomes. They extend attachment theory to adolescents' relationships with friends.

Mitchell, Carey Usher; LaGory, Mark. 2002. Social Capital and Mental Distress in an Impoverished Community. *City & Community*, 1(2): 195-216.

According to recent investigations of social capital, this social resource represents a key ingredient in a community's capacity to respond to environmental challenges and promote change. This article investigates the significance of social capital for the health and well-being for inner-city residents using data collected from a sample of household decision makers residing in a high-poverty, racially segregated urban neighborhood in a mid-sized southern city (N = 222). A psychosocial resources model of distress is employed to explore the role of social capital as a critical social resource mediating the impact of poverty-related economic and environmental stressors and mental health. While bridging social capital is actually positively related to mental distress. Bonding social capital appears to increase individuals' levels of mental distress in this impoverished community. On the other hand, a psychological resource, mastery, plays a significant role in modification of recent claims that social patently, in high-poverty, high-minority, inner-city communities, active participation in the local area comes at some cost to the individual. This article demonstrates the importance of doing further research on the social capital of inner-city areas.

Moreno, Y; Gómez, J.B.; Pacheco, A.F. 2002. Instability of scale-free networks under node-breaking avalanches. *Europhys. Lett.*, **58** (4): 630–636.

The instability introduced in a large scale-free network by the triggering of nodebreaking avalanches is analyzed using the .ber-bundle model as conceptual framework. We found, by measuring the size of the giant component, the avalanche size distribution and other quantities, the existence of an abrupt transition. This test of strength for complex networks like Internet is more stringent than others recently considered like the random removal of nodes, analyzed within the framework of percolation theory. Finally, we discuss the possible implications of our results and their relevance in forecasting cascading failures in scale-free networks.

Montoya, Jose M; Solé, Richard V. Small World Patterns in Food Webs. *Journal of Theoretical Biology*, Volume 214 (3): 405-412.

The analysis of some species-rich, well-defined food webs shows that they display the so-called small world behavior shared by a number of disparate complex systems. The three systems analysed (Ythan estuary web, Silwood web and the Little Rock lake web) have different levels of taxonomic resolution, but all of them involve high clustering and short path lengths (near two degrees of separation) between species. Additionally, the distribution of connections P (k) which is skewed in all the webs analysed

shows long tails indicative of power-law scaling. These features suggest that communities might be self-organized in a non-random fashion that might have important consequences in their resistance to perturbations (such as species removal). The consequences for ecological theory are outlined.

Newbery, David M. 2000. *Privatization, Restructuring, And Regulation of Network Utilities*. Cambridge, MA: MIT Press.

Network utilities, such as electricity, telephones, and gas, are public utilities that require a fixed network to deliver their services. Because consumers have no choice of network, they risk exploitation by network owners. Once invested, however, a network's capital is sunk, and the bargaining advantage shifts from investor to consumer. The tension between consume and investor can be side-stepped by state ownership or by regulation that reconciles private ownership and consumers' political power. Either way, network utilities operate under terms set by the state.

Okhuysen, Gerardro Andres. 2001. Structuring change: Familiarity and formal interventions in problem-solving groups. *Academy of Management Journal*, 44 (4): 794-808.

This paper presents evidence for an incremental change process in decision-making groups whereby change unfolds through self-generated interruptions. Group members initiate self-interruptions by switching their attention to social concerns. During such interruptions, members evaluate activities, propose alternative approaches and provide flexible structures that lead to superior performance. A central finding reveals that using a formal intervention in familiar groups hurts performance because pre-established interaction patterns are altered.

Pastor-Satorras, Romualdo; Vespignani, Alessandro. 2000. Epidemic Spreading in Scale-Free Networks. *Physical Review Letters* 86(14): 3200-3203.

The Internet has a very complex connectivity recently modeled by the class of scale-free networks. This feature, which appears to be very efficient for a communications network, favors at the same time the spreading of computer viruses. We analyze real data from computer virus infections and find the average lifetime and persistence of viral strains on the Internet. We define a dynamical model for the spreading of infections on scale-free networks, finding the absence of an epidemic threshold and its associated critical behavior. This new epidemiological framework rationalizes data of computer viruses and could help in the understanding of other spreading phenomena on communication and social networks.

Pennock, David M; Flake, Gary W.; Lawrence, Steve; Glover, Eric J.; Giles, C. Lee. 2002. Winners don't take all: Characterizing the competition for links on the web. *Proceedings of the National Academy of Science, USA,* Vol. 99, Issue 8, 5207-5211.

As a whole, the World Wide Web displays a striking "rich get richer" behavior, with a relatively small number of sites receiving a disproportionately large share of hyperlink references and traffic. However, hidden in this skewed global distribution, we discover a qualitatively different and considerably less biased link distribution among subcategories of pages---for example, among all university homepages or all newspaper homepages. Although the connectivity distribution over the entire web is close to a pure power law, we find that the distribution within specific categories is typically unimodal on a log scale, with the location of the mode, and thus the extent of the rich get richer phenomenon, varying across different categories. Similar distributions occur in many other naturally occurring networks, including research paper citations, movie actor collaborations, and United States power grid connections. A simple generative model, incorporating a mixture of preferential and uniform attachment, quantifies the degree to which the rich nodes grow richer, and how new (and poorly connected) nodes can compete. The model accurately accounts for the true connectivity distributions of category-specific web pages, the web as a whole, and other social networks

Shy, Oz. 2001. *The Economics of Network Industries*. Cambridge: Cambridge University Press.

This book introduces upper-level undergraduates, graduate students, and researchers to the latest developments in network economics, one of the fastest-growing fields in all industrial organization. Network industries include the Internet, e-mail, telephony, computer hardware and software, music and video players, and service operations in the banking, legal and airlines industries among many others. The work offers an overview of the subject matter as well as investigations about specific industries. It conveys the essential features of how strategic interactions between firms are affected by network activity, as well as, converting social interaction and its influence on consumers' choices of products and service. Virtually no calculus is used in the text, and each chapter ends with a series of exercise and selected references. The text may be used for both one and two-semester course.

Passy, Florence and Giugni, Marco. Social Networks and Individual Perceptions: Explaining Differential Participation in Social Movements. *Sociological Forum*, 16 (3).

This paper seeks to explain differential participation in social movements. It does so by attempting to bridge structural-level and individual-level explanations. We test a number of hypotheses drawn from the social networks and the rationalist perspectives on individual engagement by means of survey data on members of a major organization of the Swiss solidarity movement. Both perspectives find empirical support: The intensity of participation depends both on the embeddedness in social networks and on the individual perceptions of participation, that is, the evaluation of a number of cognitive parameters related to engagement. In particular, to be recruited by an activist and the perceived effectiveness of one's own potential contribution are the best predictors of differential participation. We specify the role of networks for social movements by looking at the nature and content of networks and by distinguishing between three basic functions of networks: structurally connecting prospective participants to an opportunity to participate, socializing them to a protest issue, and shaping their decision to become involved. The latter function implies that the embeddedness in social networks significantly affects the individual perceptions of participation.

Plug, L. J.; Werner, B. T.. 2002. Nonlinear dynamics of ice-wedge networks and resulting sensitivity to severe cooling events. *Nature* 417, 929 - 933.

Patterns of subsurface wedges of ice that form along cooling-induced tension fractures, expressed at the ground surface by ridges or troughs spaced 10-30 m apart, are ubiquitous in polar lowlands. Fossilized ice wedges, which are widespread at lower latitudes, have been used to infer the duration and mean temperature of cold periods within Proterozoic and Quaternary climates, and recent climate trends have been inferred from fracture frequency in active ice wedges. Here we present simulations from a numerical model for the evolution of ice-wedge networks over a range of climate scenarios, based on the interactions between thermal tensile stress, fracture and ice wedges. We find that short-lived periods of severe cooling permanently alter the spacing between ice wedges as well as their fracture frequency. This affects the rate at which the widths of ice wedges increase as well as the network's response to subsequent climate change. We conclude that wedge spacing and width in ice-wedge networks mainly reflect infrequent episodes of rapidly falling ground temperatures rather than mean conditions.

Podolny, Joel. M. *2001*. Networks as the pipes and prisms of the market (1). *American Journal of Sociology*, 107 (1): 33-60.

This article draws an analytical distinction between two types of market uncertainty: egocentric, which refers to a focal actor's uncertainty regarding the best way to convert a set of inputs to an output desired by a potential exchange partner, and altercentric, which denotes the uncertainty confronted by a focal actor's exchange partners regarding the quality of the output that the focal actor brings to the market. Given this distinction, the article considers how the value of "structural holes" and market status vary with these two types of uncertainty. The article proposes that the value of structural holes increases with egocentric uncertainty, but not with altercentric uncertainty. In contrast, the value of status increases with altercentric uncertainty, but declines with egocentric uncertainty. Thus actors with networks rich in structural holes should sort into markets or market segments that are high in egocentric uncertainty;

high-status actors should sort into markets that are low in egocentric uncertainty. Support for this claim is found in an examination of the venture capital markets.

Redner, Sidney. 2000. Networking comes of age. *Nature* 418, 127 - 128.
The past few years have seen an explosion of interest in so-called complex networks. In the physical sciences we are familiar with regular lattice networks of atoms, in which the local environment of each atom is identical. Such systems have traditionally been used to model the cooperative behaviour of interacting lattice systems — such as phase transitions — in which interactions are mediated by the underlying lattice. However, recent work by Steven Strogatz and Duncan Watts on small worlds and by Albert-Lásló Barabási and Réka Albert on scale-free networks has suddenly enlarged our notions of what actually constitutes a network.

Riles, Annelise. 2001. *The Network Inside Out*. Ann Arbor, USA: The University of Michigan Press.

"Networks" and other artifacts of institutional life, such as documents, funding proposals, newsletters, and organizational charts, are such ubiquitous aspects of the information age that they go unnoticed to most observers' of late modern society. In this new kind of working the ethnography of legality, Annelise Riles takes a sophisticated theoretical approach to the aesthetics of such artifacts by analyzing the experiences of a group of Fijian bureaucrats and activists preparing for the participating in the United Nations Fourth World Conferences on Women in 1995. In describing and theorizing this aspect of transnational existence, Riles enacts a new ethnographic method for apprehending the network from the inside out. Working with the premise that anthropologists are inside the network—that they are producers, consumers, and aesthetes, not simply observers, of the artifacts of late modern institutional life—she produces a fascinating study of institutional knowledge practices and makes an important contribution to the anthropology of transnational phenomena.

Roschelle, Anne R. 1997. *No More Kin (Exploring Race, Class and Gender in Family Networks)*. California, USC: Sage Publications.

Using an integrative framework, this book examines extended kinship networks among African American, Chicano, Puerto Rican, and non-Hispanic White families in contemporary America. I have selected these four racial-ethnic groups for several reasons. First and foremost, my expertise in the area of racial and ethnic minorities is on African Americans, Chicanos, and Puerto Ricans. In addition, although the National Survey of Families and Households (NSFH), from which I draw my data, include Natives Americans and Cubans, in both cases they comprise less than 1% of the sample, making comparisons problematic. Furthermore, the categories "other Hispanic" and Asian American" consolidate distinct Latino and Asian American ethnic groups, homogenizing their unique sociohistorical experiences. Finally, the inclusion of non-Hispanic White in the sample is necessary because the literature on minority families claims that they are less likely to participate in extended kinship networks than are Latinos and Blacks.

Ross, Lynda; Spinner, Barry. *2001*. General and specific attachment representations in adulthood: is there a relationship? *Journal of Social and Personal Relationships*, 18(6): 747-766.

Social and relational research assessing adult attachment often appears to be based on the assumption that adults operate, in their interpersonal relationships, with a single internal working models of attachment. The current investigation explored attachment from an alternative perspective. We hypothesized that most adults will rate their relationship orientations differently depending on the relation-ship context in which the ratings are taken. We also expected that general measures of attachment, taken outside the on text of specific relationships, would vary from attachment ratings adults report when they are referring to specific attachment relation-ships. Two hundred and twenty-four participants responded to a survey containing standardized measures (RQ: Bartholomew, 1990; Bartholomew & Horowitz, 1991) assessing Secure, Fearful, Pre-occupied and relationships. The RQ was also used to measure general attachment orientations. Results indicated that the majority of adults rated themselves differently on

each of the Secure, Fearful, Preoccupied and Dismissing dimensions of the RQ across their various attachment relationship s and that attachments rating and that attachment rating measured in response to specific attachment relationships were not equivalent to the attachment rating measured.

Shatkay, H; Kaelbling, L. P. 2002. Learning Geometrically-Constrained Hidden Markov Models for Robot Navigation. *Journal of Artificial Intelligence Research*, 16, 167-207.

Hidden Markov models (HMMs) and partially observable Markov decision processes (POMDPs) provide useful tools for modeling dynamical systems. They are particularly useful for representing the topology of environments such as road networks and office buildings, which are typical for robot navigation and planning. The work presented here describes a formal framework for incorporating readily available odometric information and geometrical constraints into both the models and the algorithm that learns them. By taking advantage of such information, learning HMMs/POMDPs can be made to generate better solutions and require fewer iterations, while being robust in the face of data reduction. Experimental results, obtained from both simulated and real robot data, demonstrate the effectiveness of the approach.

Sheu, Tair-Rong; Carley, Kathleen. 2001. Monopoly Power on the Web - A Preliminary Investigation of Search Engine. *29th Telecommunications Policy Research Conference*. http://arxiv.org/ftp/ cs/ paper s/ 0109/0109054.pdf

E-Commerce challenges traditional approaches to assessing monopolistic practices due to the rapid rate of growth, rapid change in technology, difficulty in assessing market share for information products like web sites, and high degree of interconnectivity and alliance formation among corporations. This paper has provided a fundamental framework that integrates a network and economic perspective to the search engine market. The findings indicate that (1) despite an increasing number of search engines, barriers to entry seem high, largely due to the exponential growth in the number of web sites and the non-scalability of the current search technology and collective switching costs; (2) older search engine sites tend typically to have more features to lock in users. Using standard economic indicators (CR4=58% and HHI=1163), the industry looks close to being plagued by anti-competitive practices. But based on a network adjusted HHI constructed in this paper, its value, 870, suggests that there is less cause for concern. Based on all indicators, it suggests that Yahoo would be a contender. Other possible contenders are MSN and Netscape. On the basis of results to date, some search engines keep increasing their audience reach while others don't. The trend shows that some search engines may dominate the search engine market. We suggest conducting research in the coverage performance of search engines and investigate "information search cost" as a performance indicator of search techniques. In addition, we suggest paying attention to any anti-competitive conduct (e.g. product bundling) that may lesson competition and reduce consumer welfare. The combination of network theory and economic theory to study the search engine market is a particularly powerful approach for E-Commerce.

Smaglik, Paul. 2002. Science and technology networks in Scandinavia. *Nature (Scandinavian supplement)*, Vol. 420, No. 6916.

The dominant science hubs in Scandinavia are akin to the open sandwiches favoured throughout the Nordic region — each country has its own name for, and unique approach to preparing, this delicacy. So, too, with science. Each hub has had different motivations and methods for building up local networks, as articles in this supplement reveal. But increasingly, scientific leaders in each of these areas are realizing that they cannot go it alone — even though each hub shows signs of expanding, both in terms of academic and industrial research. That realization is reflected across much of Europe. To compete with international juggernauts such as the United States, nations are realizing that they must pool their resources. The European Commission's Sixth Framework Programme for funding research, which came into effect last month, is designed to reward scientists who can build the most effective cross-border networks.

Solé, Ricard V; Cancho, Ramon Ferrer; Montoya, Jose M.; and Valverde, Sergi. 2002. Selection, Tinkering and Emergence in Complex Networks.

Complex biological networks have very di®erent origins than technologic ones. The latter involve extensive design and, as engineered structures, include a high level of optimization. The former involve (in principle) contingency and structural constraints, with new structures being incorporated through tinkering with previously evolved modules or units. However, the observation of the topological features of different biological nets suggests that nature can have a limited repertoire of "attractors" that essentially optimize communication under some basic constraints of cost and architecture or that allow the biological nets to reach a high degree of homeostasis. Conversely, the topological features exhibited by some technology graphs indicate that tinkering and internal constraints play a key role, in spite of the "designed" nature of these structures. Previous scenarios suggested to explain the overall trends of evolution are re-analyzed in light of topological patterns.

Solé, Ricard V; Montoya, Jose M.. 2001. Complexity and fragility in ecological networks, *Proc. Roy. Soc. London B* 268, 2039-2045 (2001))

A detailed analysis of three species-rich ecosystem food webs has shown that they display skewed distributions of connections. Such graphs of interaction are, in fact, shared by a number of biological and technological networks, which have been shown to display a very high homeostasis against random removals of nodes. Here, we analyse the responses of these ecological graphs to both random and selective perturbations (directed against the most-connected species). Our results suggest that ecological networks are very robust against random removals but can be extremely fragile when selective attacks are used. These observations have important consequences for biodiversity dynamics and conservation issues, current estimations of extinction rates and the relevance and de¢nition of keystone species.

Solé, Ricard V; Pastor-Satorras, Romualdo. 2002. Complex Networks in Genomics and Proteomics. In: Handbook of Graphs and Networks, S. Bornholdt & H. G. Schuster (eds.) John Wiley-VCH.

Complex multicellular organisms contain large genomes in which each structural gene is associated with at least one regulatory element and each regulatory element integrates the activity of at least two other genes. The main conclusion of this study is that the major cause of robustness comes from the interactions among unrelated genes. This mechanism would be illustrated by the following example: given a metabolic network, completely unrelated enzymes can catalyse different reactions but contribute to a pathway whose goal is to sustain an optimal €ux of metabolites. Under these conditions, mutations in genes encoding those enzymes will have little or mild effects. Simple models of complex biological interactions have been used through the last decades as powerful metaphors of natural complexity. Networks pervade biology and there is little doubt that the untangling biological complexity demands a considerable degree of simpli£cation. This view works well when generic mechanisms are at work: percolation close to criticiality in random graphs would be a perfect example in this context. Since information transfer (network communication) is a key property to all biosystems, reaching a threshold in connectivity allows information to propagate in a very effective way under a low wiring cost.

Solomon, D.H, Knobloch, L.K. 2001. Relationship uncertainty, partner interference, and intimacy within dating relationships. *Journal of Social and Personal Relationships*, 18 (6): 804-820.

The transition from casual to serious involvement appears to constitute a unique period of relationship with courtships. We suggest that the moderate levels of intimacy characterizing this phase correspond with heightened uncertainty about the relationship and greater interference from partners in everyday activities. In a test of these predictions, individuals in dating relationship (N = 341) completed self-report measures of intimacy, relationship un-certainty, partner's influence in the respondent's everyday activities, and partner's interference in those activities. Contrary to our expectations, we observed a negative linear association between intimacy and relationship uncertainty. Although the effect size was small, results indicated support for a curvilinear association between the experience of interference from partners and intimacy; as predicted, interference was greatest at moderate levels of intimacy. In addition,

results revealed an ordinal interaction between intimacy and partner's influence in everyday activities, such that the partner's influence was more positively associated with inferences at low level of intimacy than at high levels of intimacy. The discussion highlights the implications of these findings for conceptualization the development of romantic relationship.

Stokman, Frans N; Doreian, Patrick. 2001. Evolution of Social Networks. Part II. *Journal of Mathematical Sociology*, 25 (1): 138.

The Journal of Mathematical Sociology published a special issue on Evolution of Social Networks in 1996 under the responsibility of the two present guest editors. Gordon and Breach published in 1997 a volume that contained the original articles of the special issue together with three new articles (Doreian and Stokman), editors. In the first JMS special issue and a subsequent volume, a distinction was made between network dynamics and network evolution. The guest authors were primarily interested in studies that concentrated on the underlying mechanisms that induce network change. In other works, they were interested in network evolution and not only with network change. Partly as a consequence of this emphasis, most contribution in the first volume focused on theory, methods and between theory and empirical testing. This induced the guest editors to edit a second volume on Evolution of Social Networks where modeling and empirical analyses are integrated or at least combined. The present special issue contains four of such contributions. A number of others will follow next year in the third special issue on the topic of Evolution of Social Network.

Stoll, Michael A. 2001. Race, Neighborhood Poverty, and Participation in Voluntary Associations. *Unknown journal* .

This paper examines racial differences in participation in voluntary association. It extends past research by accounting for the influences of neighborhood poverty on participation. Using unique data from the 1993-94 Los Angeles Survey of Urban Inequality (LASUI), the analysis reveals that neighborhood poverty influences the number of associations to which individuals belong, even when considering differences in personal and other residential characteristics. Moreover, once the negative influence of neighborhood poverty is taken into account, black participate in more voluntary associations than do whites and other groups, while Asians participate the least. Evidence supports the ethnic community theory of blacks' greater participation, as black living in black communities participate in more organizations, particularly in ones that are political, that black who do not.

Strogatz, Steven H. 2001. Exploring complex networks. *Nature* 410, 268 - 276.

The study of networks pervades all of science, from neurobiology to statistical physics. The most basic issues are structural: how does one characterize the wiring diagram of a food web or the Internet or the metabolic network of the bacterium Escherichia coli? Are there any unifying principles underlying their topology? From the perspective of nonlinear dynamics, we would also like to understand how an enormous network of interacting dynamical systems — be they neurons, power stations or lasers — will behave collectively, given their individual dynamics and coupling architecture. Researchers are only now beginning to unravel the structure and dynamics of complex networks.

Tu, Yuhai. 2000. How robust is the Internet? *Nature* 406, 353 - 354.

Complex systems, such as the Internet, are surprisingly resistant to random errors. But a new study warns against complacency — the feature that makes the Internet immune to accidents also makes it vulnerable to attack. What can we learn from this study? The good news is that we do not have to worry about random fluctuations of these networks. The bad news is that Internet terrorists could cause great damage by targeting the most connected routers or web sites. The average performance of the Internet is reduced by a factor of two if just 1% of the most connected nodes are destroyed; and with only 4% of its most important nodes destroyed, the Internet loses its integrity, becoming fragmented into small disconnected domains.

Veeramalai, Mallika; Gilbert, David. 2002. Bioinformatics tools for protein structure. *Bioinformatics World*. 12-15.

A major goal of bioinformatics is to determine the function of each gene in the genome. The major products of genes are proteins, which are the building blocks not only of the physical structure of living organism but also of their biochemical networks. A protein's function is due to its native conformation including surface structure, binding sites and active sites plus the biochemical and biophysical properties of its constituent amino acids. A protein's structure is determined by the sequence of its amino acids, which are derived by transcription and translation from DNA (genomic coding sequences), and which fold into the final conformation.

Wellman, Barry. 1999. *Networks in the Global Village: Life in Contemporary communities*. Boulder, CO: Westview Press.

This book examines networks in a variety of communities around the world (i.e. communities in Canada, the United States, Chile, France, Hungary, Japan and Hong Kong, including communities in cyberspace). Through analysis of a variety of communities, *Networks in the Global Village* argues against a pervasive argument that communities have disappeared due to industrialization technological development, and urbanization. The book investigates the evidence that networks in communities still thrive around the world. Although the compositions and structures of communities have changed, people maintain communities through loosely or tightly knit kin and social networks. Through examinations of different networks in different communities, it reveals how the different communities manage networks distinctively under different social structures, contexts and circumstances.

Wellman, Barry. *2001* Physical Place and Cyber Place: The Rise of Personalized Networking. *International Journal of Urban and Regional Research*. 25, (2): 227-52.

We find community in networks not groups. Although people often view the world in terms of groups (Freeman, 1992), they function in networks. In networked societies: boundaries are permeable, interactions are with diverse others, connections switch between multiple networks, and hierarchies can be flatter and recursive. The change from groups to networks can be seen at many levels. Trading and political blocs have lost their monolithic character in the world system. Organizations from complex networks for alliance and exchange rather than cartels, and workers report to multiple peers and superiors. Management by multiple-connected network is replacing management by hierarchal tree and management by two-dimensional matrix (Berkowitz, 1982; Wellman, 1988; Castells, 1996). Communities are far-flung, loosely-bounded, sparsely-knit and fragmentary. Most people operate in multiple, thinly-connected, partial communities as they deal with networks of kin, neighbors, friends, workmates and organizational ties. Rather than fitting into the same group as those around them, each person has his/her own 'personal community' (Wellman and Leighton, 1979; Wellman, 1999).

Wellman, Barry; Frank, Kenneth A. 2001. Network Capital in a Multilevel World: Getting Support From Personal Communities. In *Social Capital: Theory and Research*. New York: Aldine De Gruyter

When people need help, they can either buy it, trade for it, steal it, get it from governments and charities, or obtain it through their *"personal community networks"*—supportive ties with friends, relatives, neighbors and workmates. Such ties supply *"network capital"*, the form of "social capital" that makes resources available through interpersonal ties. It is widely available, usually specialized, and unevenly distributed among people, ties and networks. Network members provide emotional aid, material aid, information, companionship, and a sense of belonging. Their *"social support"* is one of the main ways that households obtain resources to deal with daily life, seize opportunities, and reduce uncertainties.

Wellman, Barry. 2001. Computer Networks As Social Networks. *Science* 293, 14, Sept 2001: 2031- 34.

Computer Networks are inherently social networks, linking people, organizations, and knowledge. They are social institutions that should not be studied in isolation but as integrated into everyday lives. The

proliferation of computer networks has facilitated a de-emphasize on group solidarities at work and in the community and afforded a turn to networked societies that are loosely bounded and sparsely knit. The Internet increases people's social capital, increasing contact with friends and relatives who live nearby and far away. New tools must be developed to help people navigate and find knowledge in complex, fragmented, networked societies.

Wellman, Barry; Tindall, D.B. 2001. Canada as Social Structure: Social Network Analysis and Canadian Sociology. *Canadian Journal of Sociology*, 26 (4). 265-308.

We review the social network approach to structural analysis, give a brief historical sketch of its development in Canada and abroad, and provide an overview of Canadian contributions to this field. We review research in the following areas: personal communities, computer supported social networks, social capital (social mobility, social support, social exchange), culture capital, structural social psychology (social comparison and evaluation, attitude formation), collective action (mobilization for collective action and social movements, inter-and-intra movement dynamics), inter-organizational and class relations, and world systems. We discuss the core contributions of network, scholars, challenges faced by network researchers, and make suggestions for future lines of inquiry. We conclude that while social network analysis is undoubtedly an international enterprise, Canadian scholars have made core contributions on a number of fronts over the past two decades.

Wellman, Barry. 2002. Little Boxes, Glocalization, and Networked Individualism. In *Digital Cities 2*. Berlin: Springer-Verlag.

Much thinking about digital cities is in terms of community groups. Yet, the world is composed of social networks and not of groups. This paper traces how communities have changed from densely-knit "Little Boxes" (densely-knit, linking people door-to-door" to "Glocalized" networks (sparsely-knit but with clusters, linking households both locally and globally) to "Networked Individualism" (sparsely-knit, linking individuals with little regard to space). The transformation affects design considerations for computer systems that would support digital cities.

White, Harrison. 2002. *Markets from Networks: Socioeconomics Models of Production*. Princeton, New Jersey: Princeton University Press.

White seeks a richer, more empirically based alternative, and offers a more lucid, generalized treatment of the market models described in his early work, and shows how any given market is positioned in a broader exchange economy. White begins by arguing that the key to economic action is that producers seek market niches to maximize profit and minimize competition. As they do so, they base production decisions not only on anticipated costs from supplies and anticipated demand from buyers, but also on assessment of their competitors. In fact, White asserts, producers act less in response to actual demand than by anticipating it: they gauge where competitors have found demand and thus determine what they can do that is similar and yet different enough to give themselves special niche. Building on these and related insights, White creates new mathematical models of how the economy works and how the interaction of its sectors creates mutual protection from the uncertainties of business. These models provide new ways of accounting for profits, princes, market shares, and other vital economic phenomena. He shows, for example, that prince are determined by the coalescing of local variables rather than set in term of averages as implied by the "law" of supply and demand. The model of "pure" competition favored by economics is deficient, he concludes, as it fails to account for the varied circumstances of particular industries.