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Mixing Ethnography and Information Technology Data Mining to Visualize Innovation Networks in Global Networked Organizations

Julia C. Gluesing, Kenneth R. Riopelle, and James A. Danowski

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Introduction

This chapter presents an example of an embedded research design drawing on a case example of empirical research that mixed ethnography and automated data mining to analyze communication networks in global organizations. The goal of the research was to dynamically visualize structure and content across geographic, organizational, and cultural boundaries. We conducted the study described in this chapter as part of a United States National Science Foundation funded research study to examine how innovations are diffusion in global networked organizations. The theory, methods, and tools that helped us conduct our investigation are varied and many, and it will not be possible to do them all justice in this chapter. However, it is our intent to illustrate the value of combining approaches from quantitative, automated data collection and analysis with a grounded ethnographic approach. The quantitative network analysis was given greater weight in the overall study design. However, the ethnographic data were gathered in parallel with automated quantitative data collection and with special emphasis on the triangulation of data that served to both validate and corroborate results. The approach demonstrates how ethnographic methods provide both relevant content and context that can be incorporated into IT-based techniques for data mining and network analysis.

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We will demonstrate how the ethnography both validated and grounded the results we found through our analysis of electronic data as well as how the ethnography provided insights that gave our interpretation of the results depth and face validity with the

organizational members we studied. We have organized this chapter to provide the reader first with some context for our study by briefly stating the problem and the research question and reviewing the theory and research related to networks, information technology, and diffusion in organizations. Next we discuss the appropriateness of using mixed methods in our study of networks in a global organization. Third, we describe the study procedures and both the quantitative and qualitative methods and results. Finally, we conclude with a discussion of the implications for researchers of innovation networks and practitioners in global networked organizations who manage them and work in these networks.

Statement of the Problem: Diffusion of Innovations in a Global Networked Enterprise

Managing the diffusion of innovations across the global enterprise requires knowledge of both the content and the structure of complex communication networks. Existing research does not address directly a central problem faced by today's management: how best to diffuse new ideas, processes, and technologies across the global enterprise given its dynamic, emergent, and elusive character (Cross et al. 2002). Because of the dynamic and rapidly changing structure of organizational communication and innovation networks, many researchers in information systems in particular have begun to recognize the importance of better alignment between information technology infrastructure and business systems and have turned to adapting popular social network technologies for business use. IT professionals are also recognizing the utility of diffusion of innovation theory to study implementation problems (Al-Gahtani 2001; Mustonen-Ollila and Lyytinen 2003; Weitzel et al. 2003).

However, despite the ubiquity and sophistication of information technology, organizations have not taken advantage of the capabilities inherent in the information system itself as a method to manage implementation (Zack 2000). Social network theorists (Borgatti and Foster 2003), however, have recently reviewed the burgeoning field of social network research in organizational contexts and pull to the foreground the theoretical linkages of

academic network research with managerial considerations of organizational networks. Cross and Parker (2004) emphasize the explosion in computing technologies that have the potential to link network theory with practice and advance data collection and representation. It has become widely recognized in this decade that the network perspective reflects the fundamental structure of social processes. Borgatti and Foster (2003) show the exponential growth curve for studies on social networks in *Sociological Abstracts*, reviewing nearly 200 studies of social networks and organizations at both the inter- and intraorganizational levels. Organizational and communication scholars have addressed the emergence of knowledge networks in global organizations and their relationships with information-technology–driven organizations (Contractor and Eisenberg 1990). Researchers have been developing sophisticated computational simulation models for testing hypotheses about networks and information diffusion, changes in individuals' and group knowledge and interaction networks, the dynamics of cultural influence networks, and how shared beliefs evolve, focusing on their co-evolution with information technology (Carley and Krackhardt 1996; Carley 1996; Contractor et al. 1998; Harrison and Carroll 2002). *The New York Times* (Eakin 2003) is even publishing articles about the popularity of network theory, and there are best-selling books on the topic (Gladwell 2000; Barabasi 2002; Buchanan 2002; Johnson 2001; Watts 1999, 2003; Strogatz 2003). Physicists have conducted numerous studies of networks and various social practices, modeling them in high-order mathematical network terms (Newman 2002).

Network Theory

Network theory, as it has been applied to the study of human behavior and relationships, is comprised of multiple theoretical approaches. Monge and Contractor (2001, 2003) state that there are 10 families of theories that have been used to explain the emergence, maintenance, and dissolution of communication networks in organizations. With a long tradition in sociology, organizational theory, and anthropology, network analysis is a form of structural

analysis with both theory and methods intimately linked (Rogers and Kincaid 1981; Bernard and Ryan 1998; Monge and Contractor 2001; Borgatti and Foster 2003). The analysis technique is most often used to uncover the pattern of interpersonal communication in a social system by determining who talks to whom, and by investigating both structural and relationship properties of networks (Valente 1995, 1996; Cross et al. 2002). Monitoring emerging networks identifies where greater leverage can be gained for channeling diffusion resources (Cotrill 1998; Carley 1995). Our current research is not directly focused on interorganizational networks; however, there is a stream of studies that investigate interorganizational network predictors of organizational adoption of innovations (Davis1991; Haunschild 1993; Palmer et al. 1993; Powell et al. 1996; Gulati and Westphal 1999; Geletkanycz et al. 2001).

Of particular relevance to our research are recent studies of the social construction of innovation networks. Poole and DeSanctis (1990) have examined how actors and structures in a social system influence each other in a recursive relationship. In a longitudinal study conducted at a U.S. public works department, the duality of this relationship was empirically validated using the output from simulation techniques in comparison with actual network evolution (Contractor et al. 2000). Harrisson and Laberge (2002) explored the process of diffusion of a socio-technical innovation among workers of a large microelectronics firm. Network analysis revealed how innovation is constituted and the communicative form it takes by tracing the chain of arguments and responses. Burkhardt and Brass (1990) demonstrated in their study how the diffusion of an innovation altered the network structure based on the knowledge and information individuals possessed about the innovation. Investigating resistance to the introduction of ISO quality standards in a transport company, Torenvlied and Velner (1998) discovered that contagion of resistance in an informal trust network is a significant barrier to diffusing innovations.

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Diffusion of Innovations

Research on the diffusion of innovations spans almost six decades and includes more than 5,000 studies. No other field in the behavioral and social sciences represents more effort by more scholars in more nations (Rogers 2003). Diffusion is "the process by which an innovation is communicated through certain channels over time among members of a social system" (Rogers 1983:5). An innovation is an idea, practice, or object that is perceived as new by an individual or another unit of adoption. An innovation can refer to new knowledge; to new technologies such as information technologies, product improvements, or manufacturing technologies; or to a new process for doing work in organizations. While there is a large body of extant research about innovation based on product or process life cycle (Utterback 1996; Fine 2001), the study we describe in this chapter is grounded in the theoretical and methodological traditions in communication and social network research.

Our focus on measuring diffusion using data gathered from an organization's IT infrastructure does not suggest that face-to-face interaction is unimportant to diffusion. To the contrary, our ethnographic examples will illustrate how we have mapped such networks in alignment with the digital data. Moreover, we assume that IT-based networks are correlated with face-to-face network structures, following the findings of Haythornthwaite and Wellman (1998). They reported that social network data on media use among members of a co-located research group showed that pairs with closer ties used more media to communicate.

Diffusion Networks

Networks are important to the diffusion of innovation (Debresson and Amesse 1991) because they posit that the ties between individuals influence the spread of an innovation. Most diffusion models are contagion/epidemic/cohesion/relational models where information about innovation is passed from one person to another through direct contact. Valente (1995, 2005) identified only six studies that exist in the public domain that utilized network models of the

diffusion of innovation with both network data and time of adoption data. He re-analyzed data from three of the studies to demonstrate how relational network models, structural network models, threshold models, and critical mass models aid our understanding about how ideas, products, and opinions "take off" and spread with varying speed through a social system. Valente (1995) conceptualized a network threshold model that is both relational and structural and provides a more accurate measure of a person's innovativeness. He calls out the need for more network and diffusion research that measures adoption over time while collecting network data so that estimations of various network effects can be better performed (Valente 2005). To address this need we developed and tested diffusion theories by collecting data using a new "digital diffusion dashboard" methodology that utilizes companies' information technology infrastructure to create unobtrusive and continuous monitoring of their communication exchanges about an innovation to trace diffusion and also communication networks as they co-evolved. The "digital diffusion dashboard" involved tapping into the electronic data available through a company's IT infrastructure and then using off-the-shelf software[i] for display and ease of implementation. Using the analogy of the automobile dashboard, we created the diffusion dashboard and the specific gauges in collaboration with our industry partner. To validate and calibrate the dashboard and provide deeper contextual explanations for the diffusion and network patterns we observed in the dashboard, we executed an ethnographic study among organizational members working on the innovation. The next section in this chapter explains more about why we chose to combine the IT-based diffusion dashboard with ethnography and how we conducted the study mixing these quantitative and qualitative methods.

The Appropriateness of an Embedded Mixed Methods Approach to Studying Organizational Diffusion Networks

Quantitative approaches generally assume that predefined variables have similar meanings across multiple settings, ignoring the influence of context. Qualitative approaches, on the

other hand, help us to understand local perceptions and differing meanings for phenomena, explicating "the ways people in particularly setting come to understand, account for, take action, and otherwise manage their day-to-day situations" Miles and Huberman (1994:7). Bartunek and Seo (2002), in their commentary on how qualitative research can add new meanings to quantitative research, also suggest that it is important to explore how organizational members understand and make sense of constructs that are important to academic researchers, such as innovation, in order to validate their definition in local contexts. For example, studies of global teams as relatively new organizational phenomena revealed how context interacts with task and technology as well as how global team members negotiate a working culture across contexts (Gluesing 1998; Gluesing et al. 2003; Riopelle et al. 2003; Baba et al. 2004). Researchers choose methodological approaches that affect how they understand the phenomena they study. Qualitative research can be helpful, and is often necessary, to both validate and to explore organizational constructs, phenomena and local meanings, and, most importantly, the interactions that create the meanings. The combination of qualitative and quantitative methods to explore organizational networks, particularly in distributed networks and mobile work that span geographies and cultural contexts, stimulates the development of new understandings about the variety and extent of organizational members' experiences with important phenomena across global networked organizations (Meerwarth et al. 2008).

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Mixed methods exemplified by the embedded design in this study also accomplish what Stephen Barley and Gideon Kunda have called "bringing work back in" (2001:76). They argue that in order to understand post-bureaucratic organizing, especially in this era of global organizations and with structures that must adapt to flows of information, resources, and technologies that are continually in flux. The methods we employ as researchers should aid us in developing concepts and theories that are congruent with the complexities of today's

organizations and organizing processes. Social and communication networks have always been a part of organizing. Barley and Kunda (2001) believe that network theory and network analysis are important and relevant especially in today's global economy because they can help us to visualize the changing nature of work relations if we can gather longitudinal data on structures and the concrete activities that constitute them. They state that longitudinal network data that can capture the dynamics of networks complemented with a grounded approach to gather data on post-industrial work are critical to move organization studies forward and make them relevant for scholars and practitioners alike. Combining the quantitative approach of gathering network data through automated means and analyzing these data can be supplemented to great advantage by ethnographic data obtained through observation and interviews. Ethnography provides descriptive data about the patterns of work, the language people use to describe their work as well as the meaning it has for them, and contextually sensitive information about work relations. In addition, ethnographic data have the potential to generate analytic constructs that can enable foundational work in developing new theories and concepts and produce better images of post-bureaucratic organizing. White and Johansen (2005) also advance the proposition that linking ethnographic fieldwork with network analysis and theory can go a long way in explaining emergence and dynamics in complex interactions, like those that constitute post-bureaucratic organizing.

The next section describes the methods and tools we employed to conduct a study at a large global manufacturing enterprise using dynamic network analysis and participant observation supplemented by interviewing, combining quantitative methods and grounded qualitative fieldwork to understand the structure, work practices, and situated meanings of work on an innovation project as it evolved over more than a year.

Study Methods and Tools

This study of an innovation, which we will call Advanced Technology Innovation (ATI), spanned geographies and cultures in a global enterprise and hence required the collaboration of many people, including a team internal to the organization who could access and work with the IT infrastructure and facilitate the ethnographic research. We worked together over the period of one year to gather data and conduct ongoing analysis using many tools and data sets. We present here an example that is illustrative of the automated e-mail data-collection process and the ethnographic fieldwork to both validate the e-mail networks that emerged in the analysis of the e-mail data and to better understand the interactions of the actors in the network and their "native" views of the innovation. We used the results of this analysis to help us construct our "digital diffusion dashboard."

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Automated Data Collection Process

After achieving approval from the legal staff in the company and from our university institutional review boards to conduct the research, the first step in gathering data was to determine the automated data-collection process, depicted in Figure 8.1 with a brief description of the basic steps as follows:

1. The project team of 298 people served as the population for the innovation diffusion study.
2. Thirty-eight people who agreed to participate in the study enabled e-mail rules.
3. Automated inspection of e-mail using the e-mail rules took place on inbound/outbound e-mails.
4. E-mails were sent to a proxy e-mail account.
5. Incoming e-mails were stored on a dedicated secure server.
6. E-mails were sorted for evaluation.
7. E-mail was converted to a Eudora .mbx file for analysis.

8. E-mail was “unpacked,” removing forwarding headers and added nested e-mails to the database of stored e-mails for analysis.

9. Analysis of e-mail data was conducted.

Figure 8.1: Here

E-mails from January 2005 through November 2007 were gathered from among the top 25 percent of the population of individuals formally participating in the project. An initial solicitation for participation was sent to the population of 298 project team members. From this group, 38 people consented to be active participants in the study, allowing us to gather and monitor their e-mails about the project. We did not gather all the participants’ e-mails, only those filtered according to a list of key words related to various aspects of the innovation project. The network of 38 participants resulted in roughly 45,000 e-mails and links among more than 2,000 people across the enterprise communicating about the project over time.

Digital Diffusion Dashboard

One of the primary goals of our research was to develop a prototype of an IT-based “digital diffusion dashboard” to help managers in a change agent role accomplish three objectives: visualize the innovation networks over time, measure the performance of the innovation network, and manage the performance of the network to accelerate innovation and increase the likelihood of adoption. While we will not discuss the dashboard in detail in this chapter, it is important to describe the metrics that are part of the dashboard and the various software tools we used to obtain different network measure that would tie into the dashboard metrics. The dashboard metrics were designed to answer seven important evaluative questions that a manager might want to know about an innovation:

1) Who Is Talking?

- Who is talking about the innovation?
- What group of the company do they represent?
- What level of the company is talking about the innovation?

2) Who Are the Champions?

- Who is central in the network?

3) How Is the Team Collaborating?

- Who is involved in the network?
- Are the right people talking?
- Is anyone missing?

4) What Is the "Buzz" about the Innovation?

- What are people saying about the innovation?

5) What Is the Emotion of the Team?

- Are people talking positively or negatively about the innovation?

6) What Is the Rate of Adoption?

- Is the innovation diffusing fast enough?
- Is it spreading throughout the organization as it should?

7) What Is the Value Proposition?

- What is the value of the innovation to the organization?

Note: The seventh metric, "What Is the Value Proposition?", is not obtained through any IT data collection but represents the business case created by management.

The dynamic social network analysis software tools[ii] helped to define the majority of the innovation metrics. Condor is the central tool that helped define the majority of the innovation metrics, providing the data used to answer the questions about who is talking to whom, who the champions are, what people are saying about the innovation, and what the rate of adoption is. Condor creates dynamic views and network statistics, which provide the macro view of change. Navicat, a graphical user interface for the MySQL database underlying Condor, is used to extract user networks and text from the Condor database for more in-depth analysis, such as comparing different groups or different times to see how network structures and content vary. Triad census software, TRIADS, is a part of the Multinet software program

and provides data about how the team is collaborating. Negopy, also a part of Multinet, provides additional information about the subgroups in the team and their collaboration. MultiNet, Negopy, Triad Census, UCINET, and NetDraw are all used to determine groups and roles and to analyze text in an iterative fashion. WordLink further defines what is being said about the innovation, and the software program Linguistic Information and Word Count (LIWC) provides the data metric about the emotion on the team. WordLink and LIWC access a single file or group of files and perform sequential analyses to each file to evaluate the positive or negative valence of the text.

Ethnographic Data Collection

The purpose of the ethnographic research was to validate the measures we gathered to construct the dashboard and to understand more deeply the perspectives of a cross section of people about the ATI product and project. We designed the ethnography to supplement the IT-based communication network analysis by providing people's perspectives on their communication relationships related to ATI, including their e-mail communication. The results of the ethnography provided a comparison of what people believed about ATI and their project-related communication with the same type of data gathered from examining actual e-mail communications.

Through ethnography we also sought to understand the meaning of the innovation to the people involved in the project and to learn what they considered to be the best things about both the project and the process as well as to gather their suggestions about how to remove some of the barriers to progress. In addition to gathering information via ethnographic interviews about people's communication networks, we also were interested in assessing qualitatively the emotion of the team to compare it with the results of the quantitative, IT-based analysis results.

The ethnographic sample included a global cross section of people involved in the ATI project to obtain a broad set of perspectives about the innovation product and innovation project process. The respondents reflected a mix of participants involved in the global project team including people from the following areas in the company:

- Office of the General Counsel
- Product Management
- Design and Ergonomics
- Project Management
- Finance
- Core Project Staff

For the example we present in this chapter, we conducted 12 semi-structured interviews and shadowed the daily activities of two people central to the project. The interview protocol can be found in Appendix A. The interview protocol included:

- Fourteen open-ended questions
- A set of communication network questions to solicit names of people with whom respondents communicated by any means about ATI and how often they communicated
- Questions about the top three people in the respondents' networks and estimates of the frequency of communication among them
- Questions about the top three people with whom the respondents exchanged e-mail about ATI and estimates of the frequency of e-mail communication among them

The shadowing was conducted by two different ethnographers over several days and included the observation and notation of the following:

1 Topic of conversation

2 Type of communication exchange (face-to-face, phone, meeting, audio or video conference, etc.)

3 Duration of the communication event

4 General communication climate or tone (e.g., positive to negative on a scale of 1 to 10)

5 Dynamics of the interaction.

The ethnographic data about the ATI innovation product and project team enabled us to build confidence in the data and results produced by our automated data-collection and analysis process. In the following section, we highlight some of the comparative study results to illustrate the power of mixing these methods.

Comparison of Automated and Ethnographic Network Analysis Results

The findings we present in this section illustrate the study results comparing two metrics on our "digital diffusion dashboard" – Emotion and Team Collaboration – as an example of both the mixed methods approach we used in the ATI study and also the value that this quantitative and qualitative approach provided to our research.

The Emotion

Figure 8.2 shows the positivity to negativity ratio over time for the ATI project. We used the Linguistic Inquiry and Word Count (LIWC) software program to evaluate the context of words used in the e-mail data. The program takes text data and determines the count and the percentage at which the participants use positive or negative emotions, words, self references, or words that refer to specific topics and other characteristics of the e-mail talk. From this tool it is possible to compute a positivity index or the ratio of the positive to negative talk of a team over time. Fredrickson and Losada (2005) developed predictors of human flourishing that they characterized as thresholds defined by a ratio of positive to negative words and defining a positivity to negativity ratio of 2.9 to 1 as the lower threshold at which people are able to perform well in a team. This threshold point of 2.9 is referred to as the "Losada Line." Teams who "flourish" have a ratio of positivity to negativity within a zone of 2.9:1 to 11.6:1. High-performing teams were found to have a ratio of 5.6:1. Above a ratio of 11.6:1, there can be so much positive affect that it may begin to lose its benefit in helping teams to flourish,

instead creating a “halo” effect which can cause team members to lose sight of important barriers or obstacles that must be overcome. The Losada Zone (Fredrickson and Losada 2005) characterizes an environment that allows behavioral flexibility, innovation, and creativity. In the chart depicted in Figure 8.2, it is evident that the ATI project team was flourishing in the Losada Zone and was engaging in positive talk, or Buzz, about the innovation.

Figure 8.2: Here

The analysis of the ethnographic data validated the results of the LIWC positivity index. We analyzed the responses across the interviews and coded them for positive and negative words. There was a predominance of positive talk, but also some negative comments as well. Overall, the people we interviewed considered the product to be innovative and a “thoughtful application of existing technologies to better meet the needs of the customers.” “It is absolutely the right thing to do,” and “It is very exciting.” People think the product is important because it will drive people to the stores and lead them to buy the company’s products. People are realistic about the constraints inside the company and about the competitive pressures. They also see the need to keep pushing the innovation envelope and to fight against a mentality of negativity. People stated that the product is taking the company to the next step of technology improvements, but also that it’s a “lot of work … it’s complex” because it crosses so many different parts of the company. It is a challenge of global coordination.

According to those interviewed, a “best thing” about the product is not the product itself, but the set of design principles that govern the product, “the things that should govern the products that we release, and those principles like motherhood and apple pie, be attentive to your customers’ needs, be connected – allow customers to connect to other parts of their lifestyle; be approachable – trigger the customer’s curiosity and encourage exploration, and be

clear – provide information that they want and need within the context is right, and use a language that they're familiar with."

The execution of the product requires integration in process as well, which people see as another "best thing." One respondent said, "People were coming together, design, engineering, human factors, marketing, executives, etc. … we're all coming together and collaborating early on and openly about what this system should be, and to me this is a different way we do things at the company." This process is producing a product that is truly a "human machine interface change" that is "based upon real customer feedback" and a "holistic experience."

When the interview respondents talked about the ATI project itself, they most often mentioned the learning involved in the radical innovation, both product and process, that the project has required. They stated that the new ways of working in a global, cross-functional collaborative project helped break down traditional barriers, both cultural and organizational. They also mentioned as top-of-mind the involvement of the right kind of people to bring energy to the project and to do the kind of problem-solving required to work in new ways on a breakthrough product. The egalitarian aspect of the teamwork is also a factor that the interviewees saw as contributing to the project's progress and expected success. The openness to perspectives was considered critical to the new ways of working and to inventing new solutions to problems. Some of the first thoughts that people mentioned also concerned the emerging partnership with Europe to create a Global ATI product. They talked about "roadblocks from overseas … a little bit of friction with North America and Europe being connected … so now what they already have on the road we are now trying to force fit into what ATI was and so that's now defining what ATI is, is what Europe already has. That goes right back to the first thought, the ideal versus the reality." However, the project has not "strayed that much away from the original idea."

It is clear from these example results that ethnographic interviews are consistent with an elaborate nature of the talk that is characterized by the positivity index depicted in Figure 8.2. The talk also reflects the views of those interviewed about the nature of their team processes and collaboration. They were positive about the collaborative way they worked and about their connections across corporate and geographic boundaries. The same type of result was evident in the network analysis that we conducted on both the automated and the ethnographic network data we gathered.

Team Collaboration

To illustrate how we analyze data we gather using IT-based, automated data-collection methods and ethnographic data to analyze the collaborative communication network in the ATI project, we have chosen two examples that depict the communication network by organizational level and the reciprocity in communication among the team members. We begin with a discussion of the IT-based e-mail collaboration network and then describe the characteristics of the collaboration network that emerged from the ethnographic interviews.

IT-Based E-Mail Collaboration Network

The automated process for analyzing the communication network for the ATI project involved a longitudinal analysis of e-mail. The example we include here shows how we created a "picture" of the overall collaboration across time by using Multinet and a triad census to characterize the network communication patterns across levels of the organization. The e-mail data were rich enough to allow for coding of individuals by organizational level as well as according to the linkages and reciprocity in their e-mail communication. A collaborative communication network will have communication links across levels and between people in the same level and a high proportion of fully reciprocated triads. The triad census profile is based on 16 unique triad communication types where a triad is the interaction among three nodes. Each type is a three-digit comparison of links among three individuals

where the first digit represents the number of reciprocal links among people in the triad, the second digit represents the number of one-way links, and the third digit represents instances of no communication. A triad in which there is no communication among the three people will have a three-digit descriptor of 003. A fully reciprocated triad will have a description of 300.

Figure 8.3 displays the triads across levels within the ATI e-mail communication network. The even distribution of 300 triads throughout the many levels of the organization and network indicates that there is a strong linkage across the network and active collaboration among the team members.

Figure 8.3: Here

The Ethnographic ATI Collaboration Network

In the interviews, the respondents were asked to describe their communication networks. Specifically, they were asked whom they communicate with about ATI through any means and to estimate how often they communicate with these people. Next the respondents were asked to name the top three people they communicate with among those they had named. They were also asked to name the top three people with whom they exchange e-mail about ATI. These questions were intended to determine the structure of the overall ATI communication network for the 12 interview respondents and to provide some insight about the similarities and differences between their overall communication network and their e-mail network.

The findings of the ethnographic network analysis are presented in the next section and include a description of the overall network and of the top three communication and e-mail relationships followed by a comparison of them.

The Overall Communication Network

The 12 interview respondents named a total of 328 people with whom they communicated. The number of relationships that respondents named ranged from 2 to 134, with an average of 27 names. Figure 8.4 is a map showing the network relationships of all 12 respondents with their named relationships. The map shows a similar pattern of communication across hierarchical levels in the organization to that revealed by the data collected through the automated e-mail process.

Figure 8.4: Here

The single dots toward the left of the graph represent the 12 interview respondents and the clustered dots on the right indicate the people respondents say they communicate with about ATI. The network is quite extensive given that it represents the communication network of only 12 people who were interviewed.

The Top Three Communication Relationship Network

The interview respondents were asked to name the top three people with whom they communicate about ATI, illustrated in Figure 8.5. One respondent was only able to name two people; therefore there are a total of 35 people in this "top three" communication network.

Figure 8.5: Here

The highest concentration of people in the center of the network represents those who have the highest amount of interconnection in the network, those centrally involved in the delivery of the ATI product.

The group structure was confirmed using the software program Negopy. The Negopy analysis revealed that there is only one group in the top three communication relationship network. Figure 8.6 shows this single group uncovered by the Negopy analysis.

Figure 8.6: Here

In Figure 8.6, the dots clustered in the middle indicate the single subgroup in the network. The outer dots represent people who are more loosely connected but still part of the same group. On average, the 12 respondents say they communicate with the 35 people in the top three communication relationship network several times per week.

The Top Three E-Mail Relationship Network

The 12 interview respondents were asked to name the top three people with whom they e-mail about ATI. Figure 8.7 shows a network map of the 35 people in the top three e-mail network.

Figure 8.7: Here

In Figure 8.7, there appear to be two distinct subgroups that make up the e-mail network. This group structure was confirmed using the software program Negopy. The Negopy analysis revealed that there are two groups in the top three e-mail relationship network. Figure 8.8 shows the two groups uncovered by the Negopy analysis.

Figure 8.8: Here

In Figure 8.8, the dots at the top of the graph represent one subgroup in the network, a core group of central staff intimately involved in the execution of the ATI project. The small, light gray cluster of dots at the bottom center of the graph represents a second subgroup comprised of program representatives and those involved in functional support groups outside the core engineering staff.

On average, the 12 respondents say they communicate via e-mail with the 35 people in the top three e-mail relationship network somewhere between several times a week and weekly, slightly less often than they say they communicate in the top three communication network relationship overall.

Comparison of the Top Three Communication Relationship Network and Top Three E-Mail Relationship Network

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To understand how the top three communication relationship network compares with the top three e-mail communication network we computed the overlap between the two networks. Table 8.1 presents the results of this analysis. Approximately 66 percent or 23 of the 35 people named in these top three networks were the same. Thirty-four percent or 12 people were different between the two networks. There is significant overlap in the two top three networks.

Table 8.1: Here

Five of the 12 people who were interviewed named the same people as part of both their communication relationship network and their e-mail relationship network. Four people named two out of the top three people as part of both networks. One person said that one out of the three people in the communication network was also part of the e-mail network. Two people said there was no overlap at all between the people in the communication network and the e-mail network. Further examination of the data revealed that the people with the most overlap in their communication and e-mail networks are those who are part of the central core team on the project who work most closely with one another. Those who report the least overlap tend to be people in managerial positions who serve as liaisons across groups. Figure 8.9 represents a network map of the combined top three communication and e-mail networks.

Figure 8.9: Here

Negopy analysis revealed that there is only one group in the combined top three network. The few links in light gray at the center of the graph indicate those relationships that are the same across the two networks. The dark gray links represent the top three e-mail-only links that are not part of the top three communication network. E-mail is clearly an important communication tool in the ATI team. It complements and extends the communication

relationships, especially in linking cross-functional groups, and is a good representation of the overall communication network in the ATI team.

Shadowing and Collaboration Patterns

The shadowing of the daily activities of two people in the team on several different occasions was designed to supplement the data gathered through the interviews. Shadowing revealed that communication across boundaries takes place through many different means on a continuing basis: in meetings, brief hallway conversations, and in phone calls as well as through e-mail. The e-mail activity was minimally observed in the shadowing, confirming that the face-to-face communication activity is a strong network component among the core people in the ATI project. The meetings provided face-to-face communication links across functional boundaries and levels in the company. E-mail provided these same communication links but was less collaborative and more focused on documentation and the general giving of direction to team members. The shadowing confirmed the results of the network analysis groupings and how e-mail is used.

The ethnographic study provides evidence that there is significant overlap between the overall communication network for ATI and the e-mail network. Where the e-mail network is different, it is used to link people across distance and functional boundaries and makes an important contribution to the integration of the ATI team. E-mail appears to be an accurate representation of the ATI communication network as a whole and we could be confident that the "digital diffusion dashboard" tool that we are prototyping would be useful for innovation managers in monitoring the emotion and the collaboration in the team.

Conclusion

In this chapter we have demonstrated how a quantitative, automated approach and a qualitative, ethnographic approach were used to investigate collaboration and innovation in a global networked organization. Taken together, they can enhance both understanding and

explanation of network patterns, particularly when the development and diffusion of innovation are facilitated by information technology yet are influenced by local contexts and meanings. The example we presented of a global innovation team in a large manufacturing organization involved thousands of people who were spread across the organization and were in different countries. We were able to harness information that already flows through the company's IT communication infrastructure. In this case we relied on e-mail to look into the company's innovation processes. Detailed analyses of the data we collected using automated means make it possible to create an IT-based "digital diffusion dashboard" to monitor metrics in near real time about a collaborative innovation network that is extensive and spans geography, an analysis task that would be practically impossible using the usual network surveys that would have required extensive time, effort, and travel. The examples provided in this chapter illustrated how both emotion and collaboration can be analyzed using e-mail data and several software tools. Calculating a positivity index provides a measure of positive to negative talk in e-mails and a metric to assess the emotional state among non-collocated team members. Our analysis also showed how collaboration took place across levels of the organization and the extent of the collaboration as measured by the number of triads we found within and across levels.

New combinations of methods for who-to-whom network analysis of e-mail, positivity indexing, and hierarchical modeling of networks are particularly useful in the new world of intensive and extensive information exchange through technology use in organizations. We can gain increased understanding of the diffusion of technological innovations in IT-based environments and global networked organizations where innovations are appearing in greater numbers at a faster pace and diffusing more rapidly, often facilitated by global teams. Automated means of data collection, coupled with powerful software tools for analyzing both text and networks, hold great promise for mapping the contours of global networked organizations and the organizing processes themselves in near real time and over time.

Yet an understanding of micro-organizational processes and contextual variation in both meanings and behaviors is necessary if we are to avoid a simplified, overly undifferentiated or homogenized view of postbureaucratic organizing. The IT-based analytics can tell us much about how networks are structured and how they evolve as well as about the central messages that flow through the communication networks. However, ethnography can help us uncover new patterns of work, emergent roles, and different meanings for an innovation within global networks. For example, in our shadowing of team members we observed that almost everyone was constantly on the move from meeting to meeting and location to location, spending little time at their desks. People were sending and receiving e-mails on their phones and using them for other important business functions as well. This pattern would not have been evident in an analysis of the automated data. It was very important for us to learn about how e-mail exchange takes place so that we could design a dashboard for managers that would work on smart phones and not just on the desktop.

Network analysis of the data we gathered through our interviews was very closely matched to the patterns we found in the analysis of our e-mail data. We learned that face-to-face networks differed from e-mail networks primarily because e-mail was generally the only option for communicating across distance. However, our interviews also revealed that there were different patterns of e-mail use in Europe and in the United States. In the primary European location, managers did not engage in e-mail exchange with those whose offices were nearby; interpersonal communication was the norm. Our analysis of the e-mail networks alone did not reveal this practice.

It is our belief that to understand global organizing, especially in the postindustrial or postbureaucratic organizations that are enabled by information technology, mixing research methods is a good way to accomplish both depth and breadth of understanding and to keep pace with emerging patterns and meanings. This type of research will be facilitated by ever

more sophisticated information technologies and analytical tools but will also need to be grounded in context and conducted by a team of researchers who can observe and talk to people as they engage in their day-to-day work activities. Quantitative and qualitative methods, automated IT-based data collection, and in-depth ethnography are complementary and should be a necessary part of research design for organization studies going forward. Researchers also need to have an understanding of both quantitative and qualitative methods and their strengths and weaknesses, to know best when and how to use these complementary methods. We advocate a position of "both–and" and not "either–or", favoring an embedded design, mixing methods to design and execute organizational network studies that will be both comprehensive and explanatory. We have tried to show in this chapter that it is possible to design research that takes full advantage of information technologies to gather large amounts of data for data mining and network analysis, but also to embed qualitative methods in parallel and in a measured, targeted way to maximize the richness of results while minimizing the costs usually involved in long-term, labor-intensive ethnographic studies.

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Appendix A. Interview Protocol

Start Time: (e.g., 10:05 a.m.)

End Time: (e.g., 11:00 a.m.)

Part I

1. First, when you think of the ATI product, what thoughts first come to mind? [3 Probes: What else? Other thoughts? Anything else?]
2. What are the best things about the ATI product? [3 Probes]
3. Now, when you think of the ATI project itself, what thoughts first come to mind? [3 Probes: What else? Other thoughts? Anything else?]
4. What would you say are the best things about the ATI project? [3 Probes]
5. What aspects of the ATI project might need improvement? [3 Probes]

Part II

6. Who are the people you communicate with about ATI? Tell me their names. [Multiple Probes until they can think of no others]

Name	Frequency of Communication								
	1 Multiple times per day	2 Daily	3 Several times per week	4 Weekly	5 Several times per month	6 Monthly	7 Quarterly	8 Less than quarterly	9 Rarely
1.									
2.									
3.									
4.									
5.									
6.									
7.									

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8.									
9.									
10.									
11.									
12.									
13.									
14.									
15.									

[Continue listing names until respondent has no further names to offer.]

7. How often do you communicate with _____? [Repeat, asking about each name given. Provide the interviewee with the list of frequency responses.]

8. Of the people you named, remind me which three you communicate with most often about ATI, through any means? Tell me their names.

   A =

   B =

   C =

9. How often do think that A and B communicate about ATI with one another (give your best estimate)? [If says "don't know," say: "Then give your best estimate, please."]

   ___ Multiple times per day

   ___ Daily

   ___ Several times per week

   ___ Weekly

___ Several times per month

___ Monthly

___ Quarterly

___ Less than quarterly

___ Rarely

___ Never

10. How often do you think B and C communicate? [If says “don’t know,” say: “Then give your best estimate, please.”]

___ Multiple times per day

___ Daily

___ Several times per week

___ Weekly

___ Several times per month

___ Monthly

___ Quarterly

___ Less than quarterly

___ Rarely

___ Never

11. How often do think that A and C communicate? [If says “don’t know,” say: “Then give your best estimate, please.”]

___ Multiple times per day

___ Daily

___ Several times per week

___ Weekly

___ Several times per month

___ Monthly

___ Quarterly

___ Less than quarterly

___ Rarely

___ Never

12. Who are the three people that you e-mail most frequently about ATI? These three people can be entirely different ones from the previous questions or some or all can be the same. Tell me their names.

Name A (e-mail):

Name B (e-mail):

Name C (e-mail):

13. How often do you e-mail with A about ATI?

___ Multiple times per day

___ Daily

___ Several times per week

___ Weekly

___ Several times per month

___ Monthly

___ Quarterly

___ Less than quarterly

___ Rarely

___ Never

14. How often do you e-mail with B about ATI?

___ Multiple times per day

___ Daily

___ Several times per week

___ Weekly

___ Several times per month

___ Monthly

___ Quarterly

___ Less than quarterly

___ Rarely

___ Never

15. How often do you e-mail with C about ATI?

___ Multiple times per day

___ Daily

___ Several times per week

___ Weekly

___ Several times per month

___ Monthly

___ Quarterly

___ Less than quarterly

___ Rarely

___ Never

16. How often do you estimate that A and B e-mail about ATI with one another?

___ Multiple times per day

___ Daily

___ Several times per week

___ Weekly

___ Several times per month

___ Monthly

___ Quarterly

___ Less than quarterly

___ Rarely

___ Never

17. How often do you estimate that B and C e-mail about ATI?

___ Multiple times per day

___ Daily

___ Several times per week

___ Weekly

___ Several times per month

___ Monthly

___ Quarterly

___ Less than quarterly

___ Rarely

___ Never

18. How often do you estimate that A and C e-mail about ATI?

___ Multiple times per day

___ Daily

___ Several times per week

___ Weekly

___ Several times per month

___ Monthly

___ Quarterly

___ Less than quarterly

___ Rarely

___ Never

Part III

19. How does ATI fit into the company business strategy [3 Probes]

20. What do you think the outcomes of ATI will be?

22. Is there anyone that you want to talk with about ATI, but that you haven't been able to reach? What are their names and what would you like to say?

23. How do you personally feel about ATI?

24. What is helping to move the ATI innovation forward? [3 Probes]

25. What are the barriers to the ATI innovation? [3 Probes]

26. What ideas do you have on how to remove these barriers? [3 Probes]

27. What is your role on the ATI project? [3 Probes]

28. Finally, in general terms, what is the meaning of innovation?

Table 8.1. Comparison of Top Three Communication Relationship and Top Three E-Mail Relationship Networks

Network Top 3 Nominations (Communication vs E-Mail)		
Nominations	Count	Percent
Same	23	66%
Different	12	34%
Total	35	100%

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[i] To display data as gauges, for example, we propose to use off-the-shelf modeling software such as that being developed by Bass Economics, founded by the developer of the highly cited Bass Model of diffusion (Bass 1969), which is near release of a beta version of Excel and SAS templates for modeling diffusion curves on the desktop (see www.basseconomics.com).

[ii] *Condor*<<**AU: not ital in text? same for others in this note?**>> was created by Peter Gloor (2006; Gloor and Cooper<<**AU: no Gloor 2007, do you mean Gloor and Cooper?**>> 2007) at MIT and is a network visualization program; contact: Peter A. Gloor (pgloor@mit.edu). *Negopy* was created by Bill Richards (deceased) at Simon Frasier University and is now part of *Multinet*, created by Andrew Seary at Simon Frasier University; contact: Andrew Seary (seary@sfu.ca). *UCINET* was created by Steve Borgatti, M.G. Everett and L. C. Freeman. *Pajek* was developed by Valdimir Batagelj and Andrej Mrvar at University of Ljubljana, Slovenia. *Triads* is a modification of the triad census FORTRAN software program created by Walker and Wasserman. The modification was done by Danowski and Riopelle, co-authors of this chapter; contact: James A. Danowski (jdanowski@gmail.com) and Ken Riopelle (kenriopelle@wayne.edu). *Family Tree* Maker (http://www.familytreemaker.com) is a genealogy program that makes excellent organizational charts. Linguistic Inquiry and Word *Count (LIWC)* reads text files and is used to compute a Positivity Index. It was developed by Fredrickson and Losada (2005). *WordLink* was created by Jim Danowski (1982, 1993a, 1993b, 1993c), a chapter co-author, and is a program that counts the

frequency of all uniquely occurring words and word pairs in a body of text for content analysis and to assess change over time in word usage; contact: James A. Danowski (jdanowski@gmail.com).