Chapter 57: Networked Scholarship

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1. THE TRANSFORMATION OF COMMUNITY

Community has traditionally been anchored in local, neighborhood interactions and enshrined as a code word for social cohesion. "Community" usually connotes people socially and cognitively encapsulated by homogeneous, broadly embracing groups (Hillery, 1955; Wellman, 2001a; Wellman, 2002; Wellman & Leighton, 1979). People in group-based societies deal principally with fellow members of the few groups to which they belong: at home, in school, in the neighborhood, at work or in voluntary organizations. They work in a discrete work group within a single organization; they live in a household in a neighborhood; they are members of one or two kinship groups; and they participate in structured voluntary organizations: churches, bowling leagues, unions, and the like. There have been fears since the Industrial Revolution that traditional group-based community has been "lost". From the early 1960s, the balance of analysis swung away from bewailing this purported loss of community to using ethnographic and survey techniques to discover the persistence of neighborhood communities. In the 1970s, analysts began realizing that communities were flourishing outside of neighborhoods. The proliferation of cheap and efficient transportation and communication networks in the developed world has increased the velocity of transactions and fostered interactional density. This allows contact to be maintained with greater ease and over longer distances. Since the 1970s, many studies have documented a change from local to long-distance community, with little interaction across the intervening territory between places. Few neighbors are known, and most friends and relatives live elsewhere (Fischer, 1982; Wellman, 1997; 1999a, b; Wellman & Leighton, 1979).

In the Internet age, communities and their networks have spread through the information commons. As computer-mediated-communication spread through academic communities, new uses for it were imagined. With learning as one of the primary missions of academic institutions, it is not surprising that virtual learning environments were developed. The context of the development of virtual learning environments have been influenced by a myriad of scholarly communities and networks and the virtualized relationships they provide. Our understanding of those networks can be increased through researching networked scholarship.

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2. INVISIBLE COLLEGES AND SCHOLARLY NETWORKS

Scholarly networks have existed since at least the Middle Ages. Remnants of the correspondence of ancient scholars such as Desiderius Erasmus, St. Thomas More, and others reveal that scholarly networks communicated actively during the Renaissance, continued through Enlightenment, and continues today.

The 19th-century's increase in the scale of scholarship and the Industrial Revolution's turn toward hierarchical bureaucratic organizations narrowed the focus of scholarly societies, professionalizing education, and restructuring the universities. The main bases for scholarly organization became spatial proximity or disciplinary affinity. Most scholars work in physically compact universities (or similar research centers), where they meet students and colleagues face-to-face. Yet, universities and their departments are polyglot, physically compact bureaucracies geared for organizing teaching and for administering costly resources. A department's faculty is intentionally diverse in order to serve the perceived needs of students and the public in a smorgasbord of areas. This diversity also means that university departments often are too large and diverse to be suitable venues for scholars wanting to discuss a specific problem area.

The 20th-century's proliferation of research, researchers, and research publications has meant a global increase in the number of specialists in each area. Increased specialization means that the scholars most interested in each other's work usually live elsewhere because few universities care to employ two experts on the same subject. Intellectually kindred souls find each other by forming professional associations within their discipline or interdisciplinary interest area. Such associations are rarely local, except on a small scale or when disciplinary associations are foregone in favor of transdisciplinary efforts. Scholars must go to (often-great) lengths to communicate with distant, kindred souls. Rather than wait impatiently for replies or discussions of their findings, they go to conferences, read periodicals, or circulate preliminary thoughts and findings via attachments, web-postings and blogs. In addition to formal associations, the narrowed focus of scholarship and the limited number of faculty in local proximity has fostered the proliferation of extra-university networks to support the interests of individual faculty members.

As scholars get used to seeing each other at conferences and journals and develop the habit of discussing each other's work and perhaps collaborating, all or part of their network becomes crystallized as a less amorphous *invisible college*, defined by a shared interest in a specialty and by ties of friendship, information, advice, and collaboration. The long-standing practice of scholarly communication in these networks is the foundation for understanding development and change in the academy.

Studies of scholarly networks have increased since the early 1960s when Price (1961) coined the term "invisible colleges" to describe the patterns and

structure of scholarly networks [see also Crane (1972)]. Such invisible colleges "function as a scholarly in-group within a given specialization", their research "facilitated by informal exchange of information through contacts within this social network at conferences and other forums" (Gresham, 1994: 38). Their structures are networks with crosscutting ties between sets of scholars on both the core and the periphery. The informal nature of these invisible colleges affords flexible, adaptive structures for exchanging and evaluating new ideas. Their lack of formal structure means that communication depends on the structure, frequency, and quality of scholarly ties.

Invisible colleges provide forums for sharing, disseminating, and testing new ideas, as well as for exchanging information about teaching, research, funding opportunities, academic bureaucracies, and personal situations. They promote scholarly identity and purpose and stimulate discussion of theory, methods, and findings. Ideas get transmitted more quickly and innovatively than in formal journals constrained by publication lags and orthodoxy-promoting refereeing, though this too is changing in the online era. Typically, they contain:

- a core group of elite scholars;
- a high degree of communication through formal (conferences, papers) and informal channels among members;
- frequent communication between prominent core scholars and subsets of less prominent, non-core scholars;
- interactions among core members and their adherents hold the invisible college together;
- contacts between members of invisible colleges and outsiders enable mutual exchange of information.

3. WIRING SCHOLARLY NETWORKS

Rapid developments in computer-mediated communication are associated with a paradigm shift in the ways in which institutions and people are connected. This is a shift from being bound up in small groups to surfing life through diffuse, variegated social networks. Although the transformation began in the pre-Internet 1960s, the proliferation of the Internet both reflects and facilitates the shift. To facilitate the design of communication tools to aid scholarly communication and online-learning behavior, it is useful to understand the social structure of scholarly networks, the types of media used by these networks, and the conditions under which different media are used.

Much social organization no longer fits a group-centric model of society. Work, community, and domesticity have moved from hierarchically arranged, densely knit, bounded groups to social networks. In networked societies, boundaries are more permeable, interactions are with diverse others, linkages

switch between multiple networks, and hierarchies are flatter and more recursive. People maneuver through multiple communities, no longer bounded by locality. Organizations form complex networks of alliances and exchanges, often in transient virtual or networked organizations (Bar & Simard, 2001).

How people learn is becoming part of this post-industrialization paradigm shift. There has been some move away from traditional classroom-based, location-specific instruction to virtual-learning environments. There has also been some move away from teacher-centered models of learning to student-centered models and somewhat flatter hierarchical relations have arisen. Geographically and spatially dispersed learning is part of this shift. Learning has moved beyond traditional many-to-teacher correspondence and educational television courses to computer-supported many-to-many or distributed learning.

Even before the development of the Internet, cars, planes, phones, and text-based computerized communication supported substantial communication and collaboration among physically dispersed scholars (Finholt, 2001; Finholt et al., 2002). The advent of the Internet has especially placed fewer constraints of time and place on communication. Scholars can stay in their locale to connect, interact, and collaborate with each other over great distances (Assimakopoulos & Macdonald, 2002; Finholt, 2001; Koku et al., 2001; Matzat, 2004; Mutschke & Quan-Haase, 2001). Now-traditional email and Web sites are being joined by online audiovisual technologies supporting collaborative work (Barrett, 2000; Churchill et al., 2001; Ragusa & Bochenek, 2001). Distance education programs offer a variety of courses, supplementing traditional means of instruction with computer-mediated lectures, discussions, activities, and projects (Harasim et al., 1995). In some cases, computer-mediated communication has enabled the operation of entire university programs online (Acker, 1995; Noam, 1998). Instead of university faculties localized at their university departments, virtual faculties, formalized "collaboratories" link far-flung scholars, institutions, and research centers (Finholt, 2001). Even more prevalent are Informal collaborations among scholars[i] located in different universities that sometimes span the globe.

Computer-mediated communication is providing a technological basis for new forms of spatially dispersed, loosely bounded, networks of scholars that are more connected than the fitful, amorphous relationships of the past and less physically proximate and bureaucratically structured than contemporary universities. These networks of scholars are closer to the idea of the invisible college, and perhaps before the invisible college arose—the republic of letters. Those institutions were distributed networks of intellectuals and scholars that shared knowledge and communicated with each other over large distances. Of course, the velocity of communication is now more rapid; distant scholars stay in touch more; and instant messaging, email, and attachments fill gaps between face-to-face meetings.

The possibility for all to communicate rapidly with all via Internet technologies, no matter where located, has created hopes that peripheries would become as well-connected as centers. As distance matters little for computer-mediated communication, spatial isolation should not be a problem, though other barriers still exist, such as those based as on language or state policy. As all become connected to all, formerly disconnected persons, groups, and branch campuses should be as able as those at the center to communicate with others. This should affect the structure of scholarly networks: As email, instant messaging blogs, and attachments of text and data help to maintain direct ties, social density increases and the periphery—whether spatial, social, organizational, or scholarly—can become better connected with the core or cores, should a plurality of centers develop.

Research has shown that computer-mediated communication supports a range of instrumental, informational, social, and emotional exchanges in work and leisure contexts (e.g., Baym, 1995; 1997; Rice et al., 1998; Wellman & Gulia, 1999; Quan-Haase & Wellman, 2004; 2005). Building on this work, there is a need to understand the types of interpersonal interactions, multiple exchanges of material and emotional support, intimacy, trust, and self-disclosure that characterize learning communities online and offline (Granovetter, 1973; Haythornthwaite, 2002; Haythornthwaite & Kazmer, 2002; Marsden & Campbell, 1984; Wellman, 2001a; Wellman & Berkowitz, 1988).

The changes in how people socialize in the network society have created a need to develop new models for conceptualizing and measuring community. Considering that socializing occurs beyond the boundaries of the local neighborhood, workplace, or school, useful approaches define community not in terms of locality, but as social networks of interpersonal ties that provide sociability, support, information, a sense of belonging, and social identity (Castells, 2000; Wellman, 2001a; Wellman et al., 1988). By examining people's social relationships independently of narrowly defined boundaries based on location, researchers have discovered that many people live in long-distance communities (Wellman & Wortley, 1990). Thus, this evidence suggests that industrialization did not destroy community, but helped transform its composition, practices, attitudes, and communication patterns. This finding parallels what we might assume: virtual learning environments will not destroy learning or scholarly communities but will transform them to some extent.

Social network analysis provides an approach that can facilitate understanding communities. Viewing community as comprising social networks of relations enables analysts to examine the types of interactions—such as information, emotional support, material support, companionship—which affect online communities. It facilitates the assessment of the extent to which computer-mediated communication supports online learning communities with low levels of centralization and hierarchy (Ahuja & Carley, 1999; Haythornthwaite & Kazmer, 2002).

Much research on computer-mediated communication has focused on how the characteristics of different communication media affect what each medium can convey (Garton, et al., 1998; Wellman & Haythornthwaite, 2002). Such characteristics include the richness of cues a medium can convey (for example, whether a medium is text only such as email or also includes visual and auditory cues), the visibility or anonymity of the participants (video-mail versus voice mail); whether communications identify the sender by name, gender, title; and the timing of exchanges (e.g., synchronous or asynchronous communication). Until recently, social scientific research into computer-mediated communication has concentrated on how individual users interface with computers, how two persons interact online, and how small groups function online. Much less attention has been paid to how computer networks fit into the broader social networks and contexts in which these individuals, duets, and groups are connected. Yet, the social relationships that people have with each other are embedded in social networks that affect their social resources, mobility, happiness, and work habits (Wellman, 1999a; 2001a).

Social network analysis stresses the importance and patterns of relationships among interacting units: people, organizations, states, etc. The social network approach enables analysts to go beyond viewing relationships only in terms of groups and isolated duets. It incorporates into research a set of structural variables such as the density, clustering, heterogeneity, and multiplexity of networks (Ahuja & Carley, 1999; Berkowitz, 1982; Scott, 1991; Tindall & Wellman, 2001; Wellman, 1998; 1999a; Wellman & Berkowitz, 1988; Wasserman & Faust, 1994). Social network analysts have developed procedures for seeing how different types of relationships inter-relate, detecting structural patterns, and analyzing the implications that structural patterns have for the behavior of network members. For example, the fact that Person A and Person B interact online may be understood better if one takes into consideration their offline reporting relationships to Person C, the company Vice President.

Thinking about relationships in terms of social networks rather than in groups can allow analysts to examine the social contexts of online relationships and focus on the potential of computer-mediated communication to support less-bounded, sparsely knit interactions (Fulk & DeSanctis, 1995; Fulk et al., 1987; Rice et al., 1990; Wellman & Gulia, 1999; Wellman et al., 1996). For example, analysts may enquire whether there is a core and periphery in a particular network structure and then examine how involvement in such structural blocks helps explain the behavior and attitudes of network members. For example, do peripheral people send more email and do they communicate only with members of their own clusters or with others?

Network analysts also look at both *whole networks* and *personal networks* (Wellman & Berkowitz, 1988). Whole network analyses look at patterns of

relationships in a social system, be it a set of scholars or a set of states. Personal network analyses look at each person's own network, such as how the networks of different scholars vary.

The social network approach has developed a battery of concepts and methods that can aid analysis of communities, online and offline. Using examples from online communities in general, and learning communities in particular [the next section of this chapter], this subsection examines the usefulness of social network concepts such as range (size and heterogeneity), density and boundedness, centrality, tie strength, and multiplexity (multiple roles) for understanding online communities and social relationships.

4.1. Network Range (Size, Heterogeneity)

The concept of network range pertains to the size and diversity of the population within the network's boundaries (Burt, 1983; Haines & Hurlbert, 1992). Networks with high range (large, heterogeneous) are good for seeking and obtaining new resources (Wellman, 1999a; Newman, 2001). On the other hand, networks with low range (small, homogeneous) are able to conserve resources and information within their boundaries.

Computerized conferences, newsgroups, and listserves facilitate and increase the range of social networks (Smith, 2000). The asynchronicity and relatively inexpensive cost of online communication transcends spatial and temporal limits, enabling system users to communicate over different time zones and maintain contact with their weak ties. Therefore, online communication links can increase the range of social networks. Given that email relationships have few social cues and social presence, the only personal detail that communicators may initially know about each other is their email addresses and signatures. Such limited personal information allows development of relations based on shared interests rather than on shared social status (Hiltz & Turoff, 1993). This may flatten the hierarchy of status found in communities and other learning environments, thus fostering more interaction among more people.

4.2. Centrality

Network centrality indicates the extent to which certain network members are prominent in a given network in terms of connectivity among network members. Centralization scores (measured as percentages) measure how variable or heterogeneous are the individual network member centrality scores. It records the extent to which a single network member has high centrality scores, and the others have lower scores. A high centralization score means a network's activity centers on a particular member.

Scholars who have high degree centrality are those with many connections with other network members. Such scholars are involved in relations with many others and could be recognized by other scholars as major channels of scholarly information and activity. Well-connected network members usually play key roles in shaping the behavior and perceptions of others in the network, particularly in the diffusion of innovations and the use of available media (Rogers, 1983; Valente, 1995). Central network members tend to use a variety of media (Haythornthwaite & Wellman, 1998), have the most positive experiences with media use (Papa & Tracy, 1988), be early adopters of new information systems, and facilitate the development of critical masses of users for the systems (Rice, 1997; Rice et al., 1990).

When directionality is taken into account, there are two kinds of degree centrality: *In-degree centrality* measures how many other network members report having a relationship with a specified person. For example, others mention scholars with high in-degree centrality as people they approach for advice or discussions. Thus, in-degree centrality is one measure of the prestige of a network member. In contrast, *out-degree centrality* measures how many other network members a person reports being connected with. Thus, it is an indicator of the extent to which a scholar reports reaching out to others.

Betweenness centrality measures the extent to which a network member occupies a location between others in the network. Persons with high betweenness are often positioned in the collaborative and communication network between people who are not directly connected. Network members with high betweenness facilitate communication and information flows. They broker information, link otherwise disconnected scholars, and transmit information across disciplinary and organizational boundaries (Ahuja & Carley, 1999; Burt, 1992; Orlikowski & Barley, 2001; Tushman & Scanlan, 1981). Thus, scholars with high betweenness are in powerful collaborative and communication brokerage positions between otherwise disconnected scholars.

Central scholars are better able to control and diffuse information. They also are better able to sustain more central communication roles because of their prestige, popularity, and grant funding (Crane, 1972). This has positive feedback effects, leading to increased conference attendance, speaking engagements, and interaction with disparate others (Perry & Rice, 1998). All of these interactions expose scholars to more ideas, make them better known within professional and policy circles, and popularize their research. This sustains the cycle of centrality and prestige because central scholars are better able to respond to promising ideas, influence the direction of policy, and retain funding.

Central scholars tend to have a more sophisticated level of knowledge of the things worth knowing: the debates and lore that are crucial for leading-edge scholarship. While peripheral scholars may be apt to discover new ideas because of their connections to other scholarly communities, central scholars may introduce such peripheral ideas into the mainstream or else

the ideas otherwise might lack attention or awareness within scientific communities (Perry & Rice, 1998). Thus central scholars both disseminate and filter, for as Erickson (1996) suggests, one of the useful consequences of being in the center is that central people know what they can afford not to know.

4.3. Density

The density of a social network is the extent to which its members are in direct contact with one other. Hence, the rate of information flow in networks partly depends on whether networks are densely or sparsely knit. Densely knit, bounded networks (i.e., "groups") usually experience frequent contact among members. In such networks, most relationships remain within the population, with the exception of a few boundary spanners and gatekeepers who maintain links outside. Frequent contact within these groups and the wide range of group activities fostered by members create close relationships among members.

In contrast, members of sparsely knit networks have many ties with people who are more closely linked to other networks. Ties in such sparsely knit networks tend to be more variable than those in densely knit networks in terms of what network members do together, how supportive they are, and how frequently they interact (Danowski, 1986; Wellman, 1997).

Computer-mediated communication supports both densely knit and sparsely knit networks. Focused task and work groups, MUDs and some moderated newsgroups, and listserves are densely knit communities. As they develop, they often evolve rules and leadership structures and require attention and commitment from their members (Kollock & Smith, 1998). Message management features of email systems can increase network density and enable friends and colleagues to keep informed. Third parties spread the word about who has help, who needs help, who has been helpful in the past, and who has been a free rider. Forwarding communications to third parties also provides indirect connections between previously unconnected people. Ease of direct reply can then transform a transitive, indirect tie to a direct tie.

Computer networks also support sparsely knit networks. Participants can send email to anyone whose address they know, and they can simultaneously belong to multiple discussion lists and chat groups. They can engage in different kinds of discussions about different subjects on different lists, varying their involvement and commitment in different work groups, maintaining connections with distant acquaintances, and forming new ties with strangers. Information may come unsolicited through blogs, distribution lists, chat groups, forwarded messages from friends, and direct e-mail from strangers connected through mutual ties. Sparsely knit networks are usually connected through weak ties to a variety of social circles. Hence, they are more apt to

be sources of new information and potential alliances (Granovetter, 1973; 1983).

4.4. Tie Strength

The strength of a tie is a multidimensional construct comprising social closeness, voluntariness, and multiplexity. Some scholars also add frequent contact to the defining criteria (Granovetter, 1973; 1983; Wellman & Wortley, 1990). Strong ties often provide more support and information, and a sense of belonging. However, Granovetter contends that weak ties are useful for specific purposes. He argues that people belong to clusters of others with whom they have strong and weak ties. Information circulates at high velocity within these clusters, and each person tends to know what other cluster members know. Hence, the spread of new information, ideas, and opportunities often comes through the weak ties that connect people in separate clusters.

Some studies have focused on the effect of tie strength on the flow of resources and information among scholars. Friedkin's (1980, 1982) study of university faculty contrasts the importance of strong versus weak ties for information flows. He shows that in the aggregate, the large number of weak scholarly ties contribute significantly to information flows. Although strong ties provide much information about activities within an organization, weak ties provide useful information about activities outside of a work group or organization (Levin et al., 2002).

Despite e-mail and IM's limited social presence and absence of social cues, their ease and ubiquity supports strong, frequent, supportive, and companionable contact (Garton & Wellman, 1995; Kling, 1996; Nie et al., 2002; Rheingold, 2000; Sproull & Kiesler, 1991; Quan-Haase & Wellman, 2004; 2005; Wellman & Gulia, 1999). So, strong and supportive are some online relationships that some participants in an online group came to feel that fellow members were close friends (Bastani, 2001; Hiltz & Turoff, 1993; Kendall, 2002). Concerns about how computer-mediated communication supports strong ties ignore the many relationships that combine online and offline communication. Computer-mediated communication is often used to maintain contact between face-to-face meetings and phone calls. Indeed, computer-mediated communication often coincides with in-person meetings, fills in gaps between, and helps arranges future meetings. Conversations began in one medium and drift to another. For example, computer scientists and programmers working in the same physical space often communicate by email and IM as well as in-person (Haythornthwaite & Wellman, 1998; Quan-Haase & Wellman, 2004; 2005). Learning communities are no different, with friendship and informal relationships—online and offline—being the fluid that lubricates the formality of collegial and academic collaborations (Carley & Wendt, 1991; Glanz, 1999; Gresham, 1994; Grimshaw, 1989; Toren, 1994).

5. TECHNET: A SCHOLARLY COMMUNITY

TechNet is a network of scholars and professionals in a North American university interested in a coherent set of issues at the intersection of the social sciences, humanities, sciences and engineering. It began informally in the early 1990s as a scholarly network at one university and formally became a university research institute "a visible college" in the mid-1990s (Nazer, 2000; Walsh & Bayama, 1996). TechNet's goals are to:

- facilitate an intellectual community of scholars, researchers, and students from a number of disciplines;
- facilitate appropriate partnerships with other universities, the private sector, non-profit organizations, and government;
- afford the intersection of the relevant disciplines a more prominent place and role within the university;
- create and support colloquia and lecture series;
- facilitate visits to the university of distinguished scholars and research working in these areas and to increase support for graduate students;
- establish one or more appropriate funded chairs and professorships;
- create additional relevant courses, and increase awareness of existing course that cross disciplinary boundaries;
- create a new collaborative degree program;
- develop and offer short professional development courses for industry and society.

TechNet's activities have been guided by a multidisciplinary steering committee that meets monthly. Membership in TechNet is voluntary and open to all faculties with an interest in TechNet's domain. At the time of our data gathering at an early stage of TechNet's development, administration was informal, with only one part-time paid administrative assistant. There were 24 members of TechNet—from the social sciences, physical sciences, medical sciences, humanities, and engineering. Members of TechNet organize and meet in a variety of online and offline forums to exchange ideas, to discuss emerging research, and to socialize. Some of these are weekly multidisciplinary seminars, annual conferences and symposia, retreats, end-of-semester/year parties.

TechNet is a scholarly network or more broadly, a community of practice with a shared history and cosmology (Barab & Duffy, 2000). Many founding members and some other members were initially linked through participation in joint research, conference attendance, reading the same journals, membership in university committees, and advising on graduate student projects. TechNet is also linked with other communities interested in the intersection of the humanities, social sciences, and technology. As one member explains in an interview:

> The ways that an entire citizenry can be much more actively and successfully involved in knowledge development and knowledge society is the core interest of mine and that of a number of TechNet members. I just think that this interest is grossly under-represented in the kind of work that is done in the university and underrepresented in formal structures. There are lots of faculty who are doing exciting things, but there are no formal structures to network together.

6. RELATIONSHIPS AND NETWORKS IN TECHNET

To learn more about TechNet, one of us (Emmanuel Koku) interviewed all 24 TechNet members in 1997–1998 about their work, friendship, and media use inside and outside of TechNet, asking members to describe their scholarly and social relations with each other TechNet member. This elicited reports about 405 pairs of scholars: their work relationship, social closeness, friendship, frequency of scholarly communication, and type of communication media used. Although much of these interviews are analyzed statistically, we also rely on notes of conversations held during the interviews and Wellman and Koku's own active participation in TechNet [this section summarizes material presented in Koku and Wellman (2004); see also Koku et al. (2001)].

TechNet scholars report having an average of five "friends" within TechNet (22% of the total membership), 10 "colleagues" (43%), 9 "acquaintances" (39%), and 4 others of whom they are "just aware" (17%; Koku and Wellman, 2004; Koku et al., 2001). They are in email contact with 19 (82%) other members and in face-to-face contact with 14 (61%). Most use email where necessary for work relationships such as discussion of research, and supplement this with face-to-face communication when they meet in person in workshops, seminars, and other collegial gatherings. These statistics underestimate the significance of face-to-face contact, as it is usually longer in duration than email contact and provides more communication bandwidth. Those pairs of TechNet scholars who are in touch are in relatively frequent contact: a mean of 20 times per year and a median of 10 times per year. As all TechNet members are comfortable with computers, they use email often: 56% of all Technet pairs have some email contact.

Email and computer-mediated communication supports face-to-face contact rather than supplants it, with members using it to arrange face-to-face meetings, disseminate news, and exchange documents. Those TechNet members using email send messages to each other at a mean rate of 24 times per year, an average of twice per month. To Technet members, non-face-to-face communication means computer-mediated communication. Only a minority use telephones, faxes, and couriers, and those who do use these media, use them infrequently. The most widely used of these are local telephone calls, used by only 25% of TechNet members to communicate with other members.

Those who telephone do so on the average of once per month (mean = 11 calls per year). Most TechNet pairs use a combination of communication media to keep connected. Thirty-two percentage use two media while 23% use three or more.

Discussing and seeking research advice are not uniformly distributed in collegial communities. The more intense the work relationship, the smaller the scholar's network. The average TechNet member discusses work with 17 other TechNet members (74%), but reads the work of only five (22%) and also collaborates with five (22%; not necessarily the same five) in research and proposal writing. These may be overlapping networks, with some scholars discussing each other's work, reading these works, and collaborating in research.

Larger scholarly networks vary more in the intensity of their communications (e.g., email) and scholarly (e.g., discussion) networks. Thus, email contact networks are as large and heterogeneous as face-to-face contact networks. Similarly, research discussion networks are larger and more heterogeneous than reading or collaborative networks. The size and heterogeneity of email networks stem in part from the ease of making contact without regard to spatial and temporal separation, and the ease of including several scholars in the same message. Moreover, forwarding email messages fosters the development of more extensive and intensive relationships among scholars. The development of such heterogeneous linkages is facilitated by TechNet's weekly seminars, workshops, and other social events that provide an in-person focus (Feld, 1981) where scholars make and sustain collegial and sociable contact with people from different disciplines [for a similar pattern in another scholarly network, see Koku et al. (2001) and Nazer (2001)]. Such networks are important avenues for the provision of social, instrumental, and emotional support and for the mobilization and co-ordination of collective activity.

Email and face-to-face contact play complementary roles and reinforce each other. Rather than substituting for face-to-face contact, those who use email often also tend to have more face-to-face contact (Chen et al., 2002; Quan-Haase & Wellman, 2002; 2005). The impact of email is not so much in what is communicated, but in who communicates with whom, how frequently, and over what distances. Despite TechNet's frequent public gatherings, face-to-face contact is more centralized than email contact. Core planners and researchers combine face-to-face, email and occasional phone contacts. Peripheral members are more apt to use one of these media to keep in touch with TechNet activities. Some rely on scheduled face-to-face get-togethers to find out what is happening administratively and intellectually. Others, who do not want to go across campus to meetings, rely on broadcast email and occasional focused exchanges. These networks have fluid and permeable boundaries for the structure of relationships in TechNet varies according to the activity being performed (Ahuja & Carley, 1999; Koku & Wellman, 2004). These networked scholars use email for a wide range of things: exchanging drafts among

coauthors, setting up meetings, asking for information, or gossiping about colleagues. Although pundits worried a decade ago about whether merely textual email could sustain a wide range of interactions—from information seeking to emotional stroking—it is the social context, more than the nature of the medium that affects whether email will be used. Expectations only a decade ago that email would only be used for purely instrumental communication appear to have been a product of an early fascination with the novelty of email and an over-reliance on McLuhan's (1962) speculation that the medium is the message.

In short, TechNet has been a success in building a scholarly network and turning it into a visible college. It has:

1. linked scholars across a variety of disciplines in the humanities, social sciences, and sciences;
2. provided a milieu where most members are aware of each other's work;
3. fostered a large amount of innovative collaborative work and discussions across disciplines;
4. integrated the use of email and face-to-face contact into useful means of communication.

TechNet has continued to develop. The scholarly network has become more visible and institutionalized. Collaborative research has become more extensive, and well-attended lecture series solidify internal communication and reach out to other scholars, policymakers, technology companies, and the public. A graduate program offers a set of core interdisciplinary courses and an extensive list of affiliated courses with collaborating scholarly departments in the social sciences, physical sciences, and engineering. Although most arrangements remain informal, there is a full-time paid director, additional paid part-time staff, and steering and executive committees.

CONCLUSIONS

We are living in a paradigm shift in which the way in which people and institutions are becoming more connected through social networks and less so through formal groups. Members of old-paradigm societies deal only with fellow members of the few groups to which they belong: at home, in the neighborhood, at work, or in voluntary organizations. They belong to a discrete work group in a single organization; they live in a household in a neighborhood; they belong to one or two kinship groups, and to one or two voluntary organizations: churches, bowling leagues, professional associations, and the like. All of these are hierarchically structured bodies with precise boundaries for inclusion.

In contrast, in new-paradigm networked societies, boundaries are more permeable, interactions are with diverse others, linkages switch between multiple networks, and hierarchies are flatter and more recursive (Castells, 2000; Wellman, 1988; 1997; 2001b; Wellman & Hogan, 2004). Although computer networks have not caused this paradigm shift, they have aided it. Email and the Web let people move between their different social networks and interests. Hierarchical barriers are lower online and less apparent. It is easy for scholars to maintain an email address book with thousands of names and to maintain multiple lists of like-minded scholars whom they can contact at the drop of an email. Email and IM provide ease and flexibility in who communicates with whom, what means they use to communicate, what they communicate, and when they communicate.

Scholarly communities of practice are not homogeneous entities, whether they are in online, offline, or both. Online mutual-learning communities consist of scholars with varying roles, levels of involvement, positions, and varying levels of connectivity with other community members (Hiltz & Wellman, 1997). Further, the structure of these relationships is related to the types and variety of communication media used. Rather than seeing the Internet as a separate interaction system, people (including scholars) use it opportunistically to fit into their everyday lives (Chen et al., 2002; Hampton & Wellman, 2003; Quan-Haase & Wellman, 2002). A substantial body of research suggests that designers of online educational communities and virtual learning environments need to take a broad look at the social networks of community members, and how media use and network structure facilitate and constrain mutual peer-to-peer learning.

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