SOCIAL NETWORKS AND INFORMATION TRANSFER

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Abstract

Information exchange, transfer and flow can often depend on the motivations of individuals who share that information. This in turn depends on the relationships they maintain with others, and the networks of information sharing resulting from their interconnections. This chapter describes the attributes of social networks that facilitate or inhibit the exchange of information, how to discover these networks, and how different configurations of networks can constrain or facilitate information transfer.

KEYWORDS

Social networks, information transfer, information sharing, information flow, actors, relations, ties, strong ties, weak ties, latent ties, social capital, network structures, network roles and positions

SOCIAL NETWORKS AND INFORMATION TRANSFER

INTRODUCTION

When people engage with others they transfer information. As they recount stories, discuss ideas, share opinions and experiences, they tell others about themselves, the activities they engage in, and the people with whom they engage in these activities. They transfer knowledge about processes, information about resources, and data about their experiences with others. This information can transfer in a one-to-one, one-to-many, or

many-to-many distribution through conversation and instruction, by example or observation, and face-to-face or mediated through computer technologies. Each such transfer forms a connection with others based on a decision about what information to reveal, where, when and to whom. Such choices are tempered by expectations of who will hear or receive the information, how far the information might travel, how sensitive or timely the information is, and how well the speaker knows the audience. Patterns of connectivity, revealed by who transfers what kind of information to whom, are both formed and reinforced by existing knowledge of others. Together, the *ties* formed by information transfers between *actors* build *networks* with routes along which information travels, bridges that carry information from one social circle to another, and cul-de-sacs where information dead-ends or circulates repeatedly among the same set of friends.

This chapter addresses the interplay between social networks and information networks, i.e., the way ties between individuals affect information transfer within social settings. The chapter addresses who shares information with whom, what facilitates or inhibits information transfer, and how network configurations affect who receives what kinds of information.

INFORMATION NETWORKS

For the purposes of this paper, 'information' is taken to refer to the intangibles of data, information, or knowledge, with no restriction on the type or purpose of the transfer, nor of the medium used for the transfer. Data on stock prices may be transferred by paper, phone or email, between brokers and clients or between friends, for investment and profit or for learning and fun. Information on health problems may transfer through online support groups, from doctor to patient, or among care-givers, for purposes of social support, medical intervention or symptom management. Knowledge on how to fix a car may be passed from parent to child through example and joint practice. In each case, while one can point to the conversation or the email text, it is not a tangible that has been transferred: the stock, the health problem, the car remain where they started. The information passes from one person to another while remaining with the originator. In this way, information networks have the potential to saturate as everyone in the network becomes aware of the same information.

As in most understandings of information, the potential for unlimited, undistorted transfer affects its value (Shapiro & Varian, 1999). In some cases, value may be preserved in the timeliness and exclusivity of the information, e.g., in having inside information, and in restricting who has access. For other purposes, information is most beneficial when widely disseminated, e.g., as in the diffusion of health information or

awareness of a product for sale. In that case, the goal is to facilitate information movement in a network. As will be discussed below, social network structures play a role in how easily information circulates, and thus our ability to transfer information easily to others or to retain control over its distribution.

MOBILIZED OR ACCESSIBLE INFORMATION

Information transfer can happen in two ways: as direct transfers from one individual to another, or by common experience, e.g., co-attendance at events, lectures, etc. This distinction mirrors one made about social capital by Lin (1999a) between *mobilized* and *accessible* resources embedded in social structures. Mobilized resources are those that are brought into use for some outcome. For example, by asking others about job opportunities, we bring out their knowledge for use in our job search. This is somewhat analogous to explicit knowledge, i.e., articulated information that we make a conscious effort to transfer. Accessible resources are those that are present in a network and potentially available for use. This is somewhat analogous to the idea of tacit knowledge, now considered at the network level. For example, the tacit knowledge of knowing how to behave in a social situation, or how to perform a particular routine task, is something that can be accessed by others, but is not normally explicitly discussed. According to Lin, social capital depends on the "resources embedded in a social structure; accessibility to such social resources by individuals; and use or mobilization of such social resources by individuals in purposive actions. Thus conceived, social capital contains three elements intersecting structure and action: the structural (embeddedness), opportunity (accessibility) and action-oriented (use) aspects" (Lin, 1999a, p. 35).

Building on this, we may think of information in terms of mobile and accessible forms. Mobile information includes transfers from one person to another of factual information, social support, skills, ideas, opinions, and collaborations, such as working together, socializing, or creating common understanding. By contrast, accessed information includes common knowledge created by living in the same culture, working in the same organization, or attending the same events. However, the information must be present in a network in order for it to be mobilized or accessible. Hence, the embeddedness of information in a network determines how much social capital (or we might say information capital) is possible for network members to access. Thus, too, the structures that connect the network to other larger circles of others also affect the social capital of a network. Lin's analyses (Lin, 1999b; Lin & Bian, 1991) stress how network structures, for example cultural hierarchies, and the embeddedness of individuals within that structure, affect their access to resources, such as information on jobs. Since many of

the resources that translate into social capital are accessed through information, there is much synergy in the work on social capital and on information transfer. We return to the ideas of mobilized and accessible information throughout this chapter.

SOCIAL NETWORK FRAMEWORK

The basics of social networks are straightforward: *actors* maintain *relations* with others which form the *tie* between them. The collective set of actors and ties forms the *network* of connections among all members of the particular social set. Analyses and visualizations of networks follow graph theory with the actors as the nodes and relations as lines between nodes. What follows is a brief description of these social network features. For more on social network analysis techniques, introductory texts, and edited collections, see the 'Further Reading' section at the end of this chapter.

ACTORS

Actors are connected by the individual relations they maintain – giving instructions, providing help, sharing resources. Collectively, this set of relations defines the tie between the actors. The challenge in examining networks is defining the set of actors to examine – i.e., the boundaries to the dataset or limit to the data collection – and the relation or set of relations to map. For studying information, many kinds of information transfer, exchange or sharing can be examined, from help on how to solve a problem to emotional support in a crisis. These different kinds of relations can describe different configurations within the network which in turn can affect the way information circulates the network as a whole.

In most cases the actors we are concerned with for information transfer are people: members of a team, employees in an organization, students in a school, or residents of a community. However, in network analyses, larger units can also function as nodes in the network. Thus, a school may be an actor in the network of educational institutions, a business may be an actor in an industry network. In these cases, information also flows and transfers, as schools receive new educational plans from boards, and businesses retain information for competitive intelligence. While the actors are different, the basic structures for analysis are the same, as are the considerations of what relations create ties between the actors, and how information transfers in networks.

TIES

A tie may consist of one relation only, and thus is entirely defined by the relation. However, most of our ties are predicated on more than one type of interaction, with the

intensity and significance of each relation varying according to our particular relationship. This is the basis of the ideas of weak and strong ties. Weak ties are based on few relations of low intensity or significance. In voluntary (rather than kin-based) ties, weakly tied pairs interact infrequently, about few different things, and via few media, and their interactions involve little or no intimacy or self-disclosure (Granovetter, 1973, 1982; Haythornthwaite & Wellman, 1998; Krackhardt, 1992; Marsden & Campbell, 1984). By contrast, strong ties involve a variety of relations, from instrumental to personal, and tend to entail reciprocal interaction (e.g., favors are returned, whether in the same or a different form).

While the weak to strong continuum is relevant across all kinds of ties, relationships may be differentiated in terms of the combination of relations the actors maintain (Haythornthwaite & Wellman, 1998; Haythornthwaite, 2006). A strong work tie can exist that does not extend to social activity, a strong friendship tie can exist that has no work component; and we have kinship ties which remain even if socially or physically distant. The nature of the relationship is bound to affect the kind of information that is likely to transfer between actors, e.g., a work-only tie is unlikely to be a source of personal social support, a friend from outside work is unlikely to be a source of specialized information about that kind of work. Such information is not embedded in the structure of the tie, and thus not accessible to the actors. However, as will be discussed below, differences in what others have access to is an important feature of information access. Thus, the friend may not know about your work, but they know about their own, and hence that information is accessible to you.

Three characteristics of relations help in assessing the nature of the tie: content, direction, and strength. *Content* refers to what is exchanged, shared or experienced together, for example, specific kinds of information, gossip, small services (e.g., babysitting), social support, cooperation and collaboration, or social services (e.g., helping neighbors). Information or resources may flow in one *direction* only, e.g., as one person gives another instructions to another, or as experts show novices how to accomplish a task. Flow may also be two-way, as gossip flows back and forth, advice is both given and received, and group members keep each other aware of innovations relevant to their business. The *strength* of a relation refers to the frequency, intensity and importance of the exchange to the pairs involved; for example, communications may be daily, monthly or yearly, care may be given occasionally or full-time, and social support may be given for a minor or major crisis.

NETWORKS

The ties formed between actors do not exist in isolation. Information transferred from one actor to another can be passed on again to others. Tracing the path the information takes describes the shape of the network. The resulting network may be dense with actors highly interconnected with others, a configuration associated with having high common knowledge because information can circulate through many channels. Or, the network may be sparse, indicating little mobilization of information among the actors. Density may appear in only some parts of the network, showing clusters and cliques of actors sharing information. Network configurations also show how particular actors may be positioned to affect information flow. Network structures and their impact on information flow are discussed further below. We turn now to considering what data to look at to assemble the network.

DATA COLLECTION

A major step in mapping networks is to determine the relation to ask about. This may be determined ahead of time, for example, if looking at the dissemination of a particular kind of health information, in using bibliometric data to examine scholarly communication (Crane, 1972; Leivrouw, 1990; Zuccala, 2006), or examining collaborations (Sonnenwald, 2007). Or, the information transfer may be determined from the activities occurring among network members, e.g., in examining what kinds of interactions constitute a community (Wellman, 1979, 1999), a learning network (Haythornthwaite, 2002a, 2008) or a collaborative team (Haythornthwaite, 2006; Haythornthwaite, Lunsford, Bowker, & Bruce, 2006).

Data to describe the network can be gathered in a number of ways. One typical way of collecting social network data is to ask the actors about their information transfers: Who have you given support to during a major or minor crisis? Who learns from you and who do you learn from? Who do you discuss important matters with? (Burt, 1984; Haythornthwaite, 2006; Wellman, Carrington & Hall, 1997). Other data sources include observations, legal and historical documents, and the wealth of traces left by our electronic activity, e.g., in emails (e.g., Diesner, Frantz & Carley, 2006), regarding who knew what and when in the Enron business scandal) or web linkages (Park, 2003). Co-authoring and co-citation data reveal networks of collaboration, collegiality and common knowledge. Although beyond the scope of this chapter to review, these data form the basis of studies of scientific collaboration and science knowledge for the fields of scientometrics and bibliometrics (Sonnenwold, 2007; Nicolaisen, 2007; Borgman & Furner, 2002). While the terms used to describe the co-author or co-citation networks are

slightly different from those used in social network analysis, the principles of connection through information use and co-orientation are the same (for discussion and comparison of social and citation networks, see White, Wellman & Nazer, 2004). Applying this to online activity has given rise to the field of webometrics which parallels the field of bibliometrics (Thelwall & Vaughn, 2004). Here again the distinction between mobilized and accessible information becomes apparent. Data may reflect mobilized information when individuals make a conscious effort to transfer information or knowledge, or connect to another's work, or the data may be drawn from accessible information, such as citation or web linking behaviors.

Network analysis also has another way to address accessible information. Asking who exchanges what information with whom produces a matrix of information exchange between people in the same social network, e.g., to and from every member of a class. This is known as a *one-mode network*, and it shows mobilized information. Data may also be collected as a matrix of people by events, e.g., showing which scholars attended which conferences. These *two-mode networks* yield both the who-to-whom network of who attended conferences in common, and the event-by-event network that shows overlap in attendees. Thus, a two-mode network is a way to reveal accessible information networks.

With the data in hand, we can proceed to analyzing the social network data. In social network studies the unit of analysis is the relation – the interaction, exchange, transfer or sharing – that occurs between actors in the network. The kinds of questions that can be used to address information transfer are different from typical questions about aggregate behavior. With the kind of network data described above, we can ask questions such as:

- Who shares what kind of information with whom?
- Who uses what kind of technology to transfer that information, and with whom?
- What does it mean to get information directly from someone, or second or third hand?
- What facilitates, or inhibits information mobility within a network?
- How does information circulate in this social system?
- How does the nature of the tie between actors affect information transfer behavior?
- How do configurations of information sharing affect who gets what kinds of information?

We now turn to what social network studies have found about our understanding of information behaviors, and how asking questions such as those above helps inform our understanding of information transfer.

SOCIAL NETWORKS AND INFORMATION TRANSFER

INNOVATION

Social network studies have revealed a number of interesting and unexpected findings about information transfer. Perhaps the first such finding relates to diffusion of innovations. Where early impressions were of the isolated innovator, adopting new processes all on their own, research by Coleman, Katz and Menzel (1966) on the adoption of tetracycline, and the many studies on diffusion and adoption of innovations carried out by Rogers (1995), found that it is the individuals most connected to news sources who first becomes aware of an innovation, and those well-connected with others who have successfully used the innovation who are more likely to adopt it. Although early adopters may be alone in taking up the innovation, they have been embedded in an information network that leads them to be ready to adopt. Cohen and Levinthal (1990) reinforced this point when they identified how some organizations are more ready to adopt innovations than others because of the preparedness of their employees. Attention to information circulating about their kind of work creates an "absorptive capacity" for innovation identification and adoption relevant to that work. Ahuja (2000) also found that collaborative ties between organizations net an information payoff. She found that "collaborative linkages can provide access to knowledge spillovers, serving as information conduits through which news of technical breakthroughs, new insights or failed approaches travels from one firm to another" (Ahuja, 2000, p. 427-428).

Social networks – who is connected to whom – matter in exposure to information, and in adoption decisions. While early adopters are well-embedded in information networks, later adopters have the example of those around them when adopting. They can see others' use, the visible results of that use, and hear about others' experiences with the innovation. Their adoption decision is heavily influenced by information from those around them. Rogers showed that influence is limited to those in close, trusted relationships with the potential adopter. Information on innovations received fourth or fifth hand is no more influential in adoption decisions than that received from mass media.

Rogers' work describes in detail the stages of innovation diffusion and adoption and also the attributes of early and late adopters. Earlier adopters are described as more cosmopolitan, and have higher socio-economic status (higher education, income). In Cohen and Levinthal's terms, they have a higher absorptive capacity, based on their greater access to and readiness to recognize information useful for their purposes; in Lin's terms, they have access to greater social capital.

STRONG AND WEAK TIES

Innovation studies show the role of strong and weak ties in information transfer. News sources (weak ties) are important for awareness of new trends; trusted sources (strong ties) are important for influencing adoption decisions. To investigate information transfer further, it is necessary to understand in more detail what composes a strong or weak tie. As noted above, the *strength of a tie* can be built on a number of different kinds of relations, but what differentiates a strong tie is the close association between the people who maintain that tie. When such pairs are asked about what they do together, they typically report more kinds of interaction, more intimacy and self-disclosure, and reciprocity in their behavior; recent studies also show they use more means of communication to maintain contact (Haythornthwaite, 2002b). They exhibit a greater desire or need to communicate, get together, share experiences, and provide what they can for each other. These attributes are highly relevant for information transfer. Those in strong ties are more motivated to share with each other what information or other resources they have, and the exchange is more likely to be reciprocal. They create strong local bonds, with each actor within that network freely exchanging and sharing what they have so that all network members are aware of and informed by the same kind of information.

The limit to this strong local network is that the people who belong to it tend to be very similar (homogeneous). They share the same socio-economic status, reinforced by where they live, where they travel, what kind of transport they use to get to work, the kind of news and television coverage they receive, what schools they attend, and the kinds of the media they use. Thus, exchanges among these people tend to pool information of a similar nature. Local groups may even further restrict information access by scheduling same-sex meetings (e.g., women's groups), or meetings held during daytime hours (thereby excluding working men and women; McPherson & Smith-Lovin, 1986, 1987; Smith-Lovin, McPherson & Cook, 2001).

A key observation to be made about social networks in general is that time spent with one person or in one network reduces the amount of time you can spend with others. Thus, each conversational choice by necessity rules out another. Even though we often feel that the Internet has extended our ability to communicate with more, distant others, we need to ask how truly different these people are. A recent study by Hargittai of college students reveals systematic differences between users of different social networking sites in terms of ethnicity and parental education (Hargittai, 2007). Hispanics and students were more likely that other ethnic groups to use MySpace, and Asian and Asian Americans more likely to use Xanga; students of parents with higher education

levels were more likely to be Facebook users. These findings suggest that even online social enclaves are perpetuating interaction among similar others. Although we may now maintain more extended networks in absolute numbers, we need to continue to question whether these are really any more varied than before in who we meet and with whom we exchange information.

Weak ties are our alternate information route. Since we know these others less well, and hang out with them less frequently, both we and they can come in contact with information different from what we attain in our own networks. Weak ties thus act as a bridge between different social circles. In Granovetter's (1973) words, this is the *strength of weak ties*. As well as weak ties, individuals we know well may also function as such bridges, keeping one toe in different social worlds, particularly between work and home, and thereby bringing information from one world to the other. In the contemporary world, this also means bringing the means of access (i.e., computers) and skills about access from one world to another, and in particular from work or school to home. Studies by the US National Telecommunications and Information Administration (NTIA), showed that in 2001, 77% of households where a computer or the Internet was used at work also used these at home, compared to 35% when these were not used at work (NTIA, 2002). Use of computers or the Internet at school provide similar ways to bring this information use knowledge into the household (Livingstone & Bober, 2005; Haythornthwaite, 2007). The relevant function here is the bridge between networks that hold different information, and the resulting shortening of the path length between those different resources and sources of information.

SMALL WORLDS

In considering information received from remote others, we cannot ignore what has become known as the 'small-world hypothesis'. This idea that individuals are separated from others by only a short chain of others was first demonstrated by Milgram (1967). In his experiment, individuals in Nebraska were given letters and asked to pass them to people they knew by first name only on the way to getting them to Milgram's friend, a stockbroker in Boston. The average chain length, i.e., the number of people a letter passed through from source to destination, was six. Hence the phrase 'six degrees of separation.'

While Milgram's experiment has become legendary (not least in part due to the 1990 film by John Guare), there has been some question about whether this would hold in later studies because Milgram only included in his calculations data from completed chains (i.e., where letters reached the stockbroker). Newman (2001) chose to examine the small

world hypothesis based on data that was more readily available and more complete, He examined the network structure of co-authorship in scientific publications from 1995-1999 with data from four major databases (Medline for biomedical research, Los Alamos e-Print Archive for theoretical physics, Spires for high-energy physics, and NCSTRT for computer science). As found by Milgram, Newman also found that scientists were, on average, separated by six degrees. Newman's work builds on that of Watts and Strogatz (1998; Watts, 2004) who created new models for networks that incorporate the clustering normally found in real-world networks. The Watts-Strogatz model has been used to show that a class of small-world networks exists defined by "some nontrivial local order, combined with just a fraction of long-range, random shortcuts" (Watts, 2004, p. 245). The western U.S. electrical power grid, movie actor connections, and the neural network of the nematode *C. elegans* have been show to be small-world networks. As Watts (2004) explains, this model has further been improved on by Jon Kleinberg to take into account that human social networks are *searchable*. At the local level, this means we do not choose people randomly for association, but instead choose them purposefully for their information, resources, companionship, etc. At the global level, we also search purposively to achieve the resources necessary for our local networks.

The ideas of local clustering and widespread connection are common themes in social network analyses. The work by researchers such as Watts, Strogatz, Newman, and Kleinberg is providing models that can be used to compare real-world behaviors to models of predicted behaviors (for a review, see Börner, Sanyal & Vespignani, 2007). This advance makes it more possible to compare and generalize across networks, and to test ideas such as Milgram's small world hypothesis. These models, when taken in conjunction with the explosion of data available online, are allowing greater progress to be made on analyzing human information behaviors. Although there is still a place for gathering data from individuals, automation makes it easier to collect and manage the data. As Newman (2001) points out, while manual data collections provide detailed information on the structure of social networks, "data that are crucial to the understanding of information or disease propagation … the studies are labor intensive, and the size of the network that can be mapped is therefore limited—typically to a few tens or hundreds of people" (p. 404). The new 'network science' provides an important addition to the tools available to understand social networks and information behaviors, complementing smaller detailed studies by identifying characteristics that hold across multiple networks and very large datasets.

ROLES AND POSITIONS

The work on network models also shows that it does not take many cross-cutting links to bring our information resources closer together. Work by Newman and colleagues (cited in Watts, 2004) has shown that five random connections in a lattice model of a network can reduce path length by half, regardless of the size of the network. Although we know that human social networks do not conform to a lattice structure, cross-cutting connections are often found that bridge different social worlds. This is often deliberately implemented to achieve that effect, for example as negotiators are brought in to settle labor disputes, and as academic institutions favor hiring graduates from other universities. An entrepreneur may find a bridging position particularly profitable. Individuals who fill what Burt has called a *structural hole*, benefit from brokering the relationship between others. Such individuals possess access to information in two worlds and can decide strategically what, how much, when, and to whom they will pass on information.

In social network terms, the entrepreneurs have a high *betweenness* score, because they sit strategically on the path that information needs to take to get from one end of the network to the other. Even if not profiting from such a position, they hold a key to information transfer in the network, often holding two parts of a network together. Again, in network terms, they are a *cutpoint* – a node that if removed leaves the network in two or more separate pieces. Network analyses that show whole network structure can reveal such positions and show were there is risk of information loss (and/or redundancy) in information routes.

Typical measures of actors examine how central an individual is in the network. The network *star* has contacts with many others, and can perform the role of passing on information or making introductions (e.g., Gladwell, 1999). They exhibit a high *degree*, i.e., a high number of connections to others. Some of these ties entail information that is primarily directed to them (*in-degree*) and some entail information outbound from them (*out-degree*). A high in-degree indicates *prominence*, i.e., others seek them out for advice, information, etc., and a high out-degree indicates *influence*, i.e., that their information is being sent out and received by others.

Across settings, many times we find people whose patterns of giving and receiving information look the same. Teachers perform the same kinds of information provision in relation to their students; libraries in different towns act in the same way in providing patrons with access to resources and the instruction necessary to use them. In these cases we see an *equivalence* in their information relations. When we discover this, we can identify particular *roles* and look for those again in other places. For example,

technological gurus (Allen, 1977) are often identified as present in many organizations. These individuals act as information gateways, monitoring new technologies as they appear and bringing that information to others. Recent work also suggests the important of information gatekeepers who know 'who knows what'. Studies of *transactive memory* show the importance to groups of knowing about themselves and where information resides within their own network (Hollingshead & Brandon, 2003; Moreland, 1999; Palazzolo 2005; Wegner, 1987). Often the gatekeeper or guru role is informal, and does not appear on any organization chart. Thus, they can only be found by asking network questions about the information flow in the organization.

Empirical discovery of roles and network structures is an essential part of a social network analysis as it reveals what is happening among network members rather than what an outsider or an inside spokesperson says is happening. It can reveal aspects of network interaction that have been ignored or simplified by conventional descriptions of work processes or social interaction. For example, socializing, play, and off-task interaction are often considered to be distractions from work, taking time away from the job to be done. But the more we examine work groups, the more we find they maintain many relations, and seemingly off-task activities such as socializing actually allow people to get to know each other and their work styles, and create trust and understanding of how to work together as a group. More has yet to be done to understand the complicated interplay between multiple relations in sustaining interpersonal relationships, group functions, and network cohesion.

NETWORK STRUCTURES

Actors within networks may demonstrate particular roles but they can only do that in relation to others in a network: the teacher acts in relation to students, the parent in relation to a child, a friend in relation to other friends. Even without a particular role, individuals' relations with others situate them in a position with respect to others in the network: the network star, the broker, the isolate are defined according to their ties (or lack of) with others in the network. In each case, the network demonstrates a shape that tells us how information travels, first between pairs, and then across the network as a whole.

Some of the first examinations of the effect of network structure on the circulation of information are those of Alex Bavelas and Harold Leavitt done in the 1940s and 1950s. In their laboratory setting, they compared information transfer between participants who were organized in a line, circle, Y or star shape. The communication structure was effected by isolating individuals and allowing them to pass messages to one or more

others depending on the structure and their position in it (for further description, see Borgatti, 1997). The most reported finding is that the star and Y structures were much faster at achieving common knowledge (knowing which symbol the team had been assigned), used fewer messages to achieve that result, and resulted in fewer errors. In short, these were found to be more efficient structures for circulating information toward common knowledge. Other findings are mentioned less often in discussions of these results. Borgatti reports that participants in the circle and line structures enjoyed themselves more. This suggests different structures may support different kinds of relationships – co-workers, collaborators, friends – and may be optimal for different kinds of tasks or outcomes. Getting work done can be frustrating if the system is inefficient and requires extra time, but a game may depend precisely on such obstacles to information transparency. Another result was that circle and line structure participants more readily said the group had a leader. Such a finding has implications for how an individual may secure a leadership position and what structures are most likely to support an emergent information leader.

Since these early experiments, studies have continued to reveal the impact of structural aspects of networks on information transfer. The simplest observation is that in networks with a high *density*, i.e., a high number of connections among actors relative to the total possible number of connections, information transfers quickly and easily around the network because it can take nearly any route to get from one person to another. With low density, information is restricted to certain routes, and thus the likelihood of receiving that information depends on being strategically placed where the information is traveling. Highway and local road structures are an ideal analogy to explain this aspect of social networks. Superhighways carry lots of traffic, of all sizes, but do not connect all towns. Smaller roads connect more local regions, but carry limited traffic as slower speeds.

Continuing to view networks as roads, looking from above at the whole network we can see places where traffic (information) reaches a bottleneck because it all goes through only one central node (consider commuting across bridges, or traveling through airport hubs). Such a network has a high *centralization*, i.e., a high coordination around one central point. *Cliques* of highly interconnected nodes may also be apparent, showing a group of actors who represent one of the local non-random orderings found in large networks. Larger aggregates may also be found as *clusters* or *components* in the network. Each of these collective units appears because of their connectivity; actors within them are more likely to have and share access to the same resources and information.

The road analogy is also useful for understanding the effect that current structures have on future structures. Highways draw traffic and attract business and residences to locate close to these roads, creating and sustaining attention to these areas. Similarly, network structures reinforce themselves. Someone who is known for having particular kinds of information continues to be sought out for that information, increasing the number of people connected to that actor. New network structures are more likely to emerge and become sustained by people with a keen interest in communicating with each other, i.e., those with stronger ties. These individuals are more likely to spend the time negotiating new ways of communicating and coming to a joint understanding of how they will communicate in a process of *adaptive structuration* (DeSanctis & Poole, 1994; Orlikowski, 2002; Haythornthwaite, 2002a, 2002b). Continued interaction also influences individuals' views of the network structure, and who knows what. Krackhardt and Kilduff (2002) have shown that dyads within interacting triads (pairs within interacting sets of three people) have more similar views of social relationships among organization members than those in the same organization not in these triads. Taking this kind of common knowledge as information about the organizational culture, they concluded that, compared to a random selection, dyad relations within these interacting triads "predict higher levels of cultural agreement" (Krackhardt & Kilduff, 2002, p. 288). Is this just because of stronger ties? Possibly, but their judgment is that "cliques lead to stronger ties and stronger ties lead to cliques in a reciprocating process that reinforces the relationship between Simmelian ties [three person ties] and agreement." (Krackhardt & Kilduff, 2002, p. 288).

Discussions of collaboration, community and groups, both offline and on, stress the development of common knowledge and shared understanding (e.g., in the development of communities of practice Wenger, 1998, or in scientific collaborations Sonnenwold, 2007), with an emphasis on strong tie needs (e.g., in the development of computer tools to support work tasks). Once initiated, strong ties can perpetuate the structure they have created, but to get there requires initiating network connections. While strongly tied pairs can influence each other and pass on information and cultural knowledge to each other, how does information circulate to weak ties or to people with no tie between them? Research on media use by strong and weak ties suggests that a group-wide means of contact (regular meeting, conference, online listserv, etc.) can create such a connection (Haythornthwaite, 2002a, 2002b, 2005). Because those with no tie or only a weak tie are unlikely to be motivated to contact and influence each other, this means of contact needs to be established and initiated by an authority beyond the individuals themselves. Scheduling meetings, enrolling people in a listserv, or establishing a wiki creates *latent*

ties – a "tie for which a connection is available technically but that has not yet been activated by social interaction" (Haythornthwaite, 2002b, p. 387). A latent tie describes the accessible information that has potential to be mobilized. The common framework provides the ground on which latent ties can be activated into weak ties with attendant information transfer and mobilization, and potentially at least some will further be enabled into strong ties. Such frameworks may also serve to maintain dormant ties, making it easier to reactivate ties, or to tap into this network for information as needed (Cross & Parker, 2004; Nardi, Whittaker & Schwarz, 2002).

PERSONAL AND NETWORK OUTCOMES

What do actors gain (or lose) by belonging to networks, and what does the network as a whole gain by member engagement? It is generally accepted that individuals who engage with others in meaningful relationships benefit in terms of personal health and well-being reflected in social, emotional, economic, and health support. Networks gain in robustness and continuity in the face of change. Both aspects highlight the role of social capital (Lin, 2001). Individuals in networks high in social capital gain access to both mobilized and accessible resources. These are "not possessed goods of the individual. Rather, they are resources accessible through one's direct and indirect ties" (Lin, 1999b, p. 468). The robustness of a network matters because social capital is found in a "durable network of more or less institutionalized relationships of mutual acquaintance and recognition" (Bordieu, 1983).

Robust networks are resilient to changes in parts, have structures that persist over time, and exhibit a stable social structure. They embody known rules of behavior and membership, increasing the likelihood that others in the network will act in an expected manner. This reduces the risk associated with making ties with others because it reduces uncertainty about how others will act and react. Known behaviors, and network conformity to them, also support self-policing, with members sharing the task of monitoring behavior, further reducing the likelihood of transgressions, as well as the burden on an individual to deal with such transgressions (Burt, 2000; Smith, McLaughlin & Osborne, 1996). Social norms of behavior in society are one example, but such robustness is also enacted through laws and contracts and their enforcement.

While individuals gain from robust networks, there is also potential for constraint as the dense network allows more visibility of behaviors and thus the potential for more monitoring and reporting of transgressions. A non-simple association exists on whether dense connectivity serves a positive or negative outcome, and this can vary with context (Degenne & Forsé, 1999). Dense personal networks can contain anxiety causing ties, or

establish rigid roles that limit what individuals can do, thereby increasing stress and its negative effects on health. However, associations with others has benefits not only in access to information, but also in support structures. One benefit often mentioned is that married people, particularly men, live longer than their unmarried counterparts. Although it is still debated whether health is the reason for marriage or the outcome, it appears that a good marriage contributes to a healthy lifestyle and thus longer life (University of Pittsburgh Medical Center, 2006).

That health and longevity appear to be associated with the size of personal networks explains recent concern over declines in the size of core discussion networks. Putnam (2000) first warned of the loss of civic engagement, the basis of social capital in communities. More recently, McPherson, Smith-Lovin and Brashears (2006) used U.S. census data to compare the number of confidants people reported in 1985 and 2004. They found a significant drop, from 2.94 confidants on average in 1985 to 2.08 in 2004, and a much higher probability in 2004 that individuals would have no confidants at all. The percentage with only one or no confidant – a level described as having marginal or inadequate personal counseling – was found to have risen from 25% to 50% of the American population. Changes in work and home and consequent lack of connection to kin and local communities explain some of these changes, but, as the authors state, "[i]f we assume that interpersonal environments are important (and most sociologists do), there appears to have been a large social change in the past two decades" (McPherson et al, 2006, p. 371), and one that deserves our attention.

SUMMARY

Information, both accessible and mobilized, form an important basis of the social capital of our personal, social networks. Our access to information provides us with opportunities for work or play, and provides the basis for getting to know others to work with, be friends with, and gain support. Co-presence in a common environment – whether considered as a common geography, online space, or intellectual discipline – situates us in an accessible information space where social network relationships, i.e., connections created and maintained by people, can mobilize information so that it is shared among network members.

This paper has focused on how patterns of information sharing among people can be examined, and how interpersonal ties and networks structures affect the way information moves among members of a network. Individuals may occupy roles or positions that provide them with access to unique resources they can then pass on when and to whom they choose. Their choice of who to pass it to is likely to depend on how strongly they are

engaged with others, favoring passing information to those with whom they are strongly tied and who are present in their close local circle. When they pass information to more distant others, it is likely the information will be new to that person or that social circle because of the differences in the experiences and information exposure across social circles.

The sum of all these contacts and information exchanges may be to increase the resources available to the network as a whole, adding to its stability and persistence, reinforcing its existing structure and culture, and generating social capital for all network members. While these outcomes are possible, some reservations exist about the benefits of highly dense, potentially socially controlling networks which may reinforce interaction only among similar others. At the same time that there is an equal concern that very sparse networks may contain insufficient support, with negative consequences for the health and well-being of individuals and their communities. In all, the social network data suggest striving for an optimal level of connectivity that promotes social capital without social control, and information access without information saturation and overload.

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