

Researching Organizational Systems using Social Network Analysis

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Abstract

A key impact of organizational systems and new information technologies is that they enable new organizational forms - the structural features or patterns of relationships and information flows of an organization. Consequently, research on organization systems can benefit from methods that are explicitly directed toward describing and measuring organizational forms and structures. This article proposes social network analysis as a highly appropriate and useful method for framing and describing the effects of organizational systems on organizational forms and structures. It discusses the concept of representing organizations as social structures and how network analysis is an appropriate method given that representation. The article draws several implications of examining the impact of organizational systems from a network view, and reviews three examples of using network analysis to examine the impact of information technology.

1. Introduction

One of the key effects of organizational systems and new information technologies is that they enable new organizational forms (see for example, the Organization Science Special Issue on Electronic Communication and Changing Organizational Forms, Vol. 6., No. 4, 1995). The study of organization forms - the structural features or patterns of relationships and information flows of an organization - lies at the foundation of organization science [14], and thus offers a useful context within which to examine organizational systems. Consequently, research on organization systems can benefit from methods that are explicitly directed toward describing and measuring organizational forms and structures. In this article, I propose *social network analysis* as a highly appropriate and useful method for framing and describing the effects of organizational systems on organizational forms and structures.

2. Social Structure

The concept of social structure captures many aspects of how organizations are affected by information technology. Social structure refers to patterning in social relationships [10], [31], [43]. These patterns tend to persist over time enough to be thought of as structure [21], [37]. Organizations can be viewed as consisting of individuals interconnected as members of social networks [31] interpreting, creating, sharing and acting on information and knowledge [7], [15], [19], [24], [28], [39], [42]. We then can think of organizational structure or form as the pattern of connections and interdependencies among organization members. Those links may reflect the formal organization defined by authority relationships (who reports to whom), the informal organization defined by actual communication and information exchange (who communicates with whom), the structuring and flow of work (who depends on whom), or the social relationships (who likes whom, who is similar to whom, etc.) [41]. These patterns can be further categorized by content, for example by the informal communication structure for coordinating a task vs. that for seeking expert advice.

By conceiving of the organization as a network of actors, structure, form and the effects of technology can be represented by describing the links (human or computer-based) among those actors. This viewpoint is especially useful for those technologies designed and implemented specifically to alter forms and patterns of organizational communication and information exchange such as email, groupware, document repositories, expert systems, and electronic markets, to name a few. For example, computer-mediated communication (CMC) has profound effects, both enabling and constraining, on the structure and content of communication links. For example, CMC enables communication without regard for time or place, yet may constrain the richness of the content of those messages [38]. Similarly, we can view an expert system or a best-practices database as a mediated communication channel between an expert and someone seeking expertise. We can then ask how replacing a formerly face-to-face interpersonal consultation process with a technology-mediated process affects the quality

and flow of information and knowledge, the roles and behaviors, and the social and organizational relationships among those involved. If we can create a micro-theory of how interaction among organization members relates to organization performance in a particular context [17], then we can further relate those patterns of interaction to performance effectiveness, thus measuring the organizational impact of the technology through its affect on the social structure of the organization (e.g., [1], [45]).

Taking a social structure approach to defining organizational forms also enables us to account for social influences on communication and information technology use. Social structure is not only influenced by the communication demands of the organization and its work environment, but by social context and institutions [1], [30]. Social content includes the culture, distribution of power, and the social norms, habits, practices, expectations and preferences held by an organization about its present and past interaction. Kling [23], in the context of organizational communication technologies, similarly proposed that

The ways in which [computer supported cooperative work systems] restructure social relationships, if at all, depend on preexisting patterns of authority, obligation, and cooperation, and an organization's openness to change.

Social structure is not necessarily bounded by the formal organization, and may apply to cross-organizational (interorganizational) relationships or collectivities of firms that form so-called network or "virtual" organizations." [1]

3. Social Network Analysis

The interaction patterns describing social structure can be viewed as a network of relations (Radcliffe-Brown 1940), therefore social network analysis is a relevant and highly useful tool for describing organizations and for measuring the effects of organization systems. Social networks are a formalism, based on graph theory [20], for representing relations as nodes and links. Depending on the level or focus of analysis, nodes may represent entities such as people, technology, groups, or entire firms themselves - whatever units of analysis form the organization being studied. This approach has been used

for extensively for measuring or describing social structure [2], [5], [10],[25], [41]. It has also been used in several studies of computer-mediated communication [9], [26], [33], [34], [35], [45], and others [32], [13] have called for further use of the social communication network paradigm for CMC research.

The central tenet of network analysis is that people's beliefs, feelings, and behaviors are primarily driven not by the attributes of individuals, but by the patterns of relationships among individuals. The network paradigm is ideal for examining a socially and organizationally based view of information technologies in that it refocuses attention away from individuals as independent users of the technology to a view of users as an interconnected set of interdependent relationships embedded within organizational and social systems (Contrator and Eisenberg 1989)

Network analysis is central to the field of structural inquiry [27] and represents the appropriate method for guiding data collection and analysis of groups when the focus is on patterns of interaction over time [29], [40]. Network analysis complements other methods well. Rich, ethnographic description is required to explain and add substance to the abstract measures and structures derived from sociometric data analysis, yet network analysis provides an opportunity to more precisely distill the structural essence out of a set of ethnographic data (c.f., [1]). Network analysis benefits from using questionnaire data received from members of a network, to provide more precise descriptive measures to inform the meaning of the derived structures. And traditional non-relational studies may be "turbo-charged" [36], by introducing social network-level metrics into studies of individual and organizational behavior. Consider, for example, the well-known Technology Acceptance Model, which attempts to explain the acceptance of information technology based on individual attributes [8]. It may be that in addition to the individual attributes typically measured, one might add a construct representing the degree to which an individual is connected to others (by communication, work flow, formal structure, or friendship) who have accepted the technology to determine their influence on users' attitudes (e.g., [33]).

Boundaries in Social Structures		
	Relational	Positional
Clusters based on:	Cohesion	Structural similarity
Key measure:	Tie strength and density	Tie similarity
Belief sharing based on:	Interaction with similar others creates shared beliefs among the cluster members	Playing similar roles creates shared beliefs among those in the same role position
Key implication for organizational systems:	<ul style="list-style-type: none"> • Impact of technology on the ability to connect and communicate with others • Impact of the technology on quality, distribution, nature etc. of existing ties • Impact of beliefs about a system on use of technology to make connections • Impact of existing relations on using technology for making new connections 	<ul style="list-style-type: none"> • Impact of the technology on the function of existing social and communication roles • Impact on the technology on the distribution and structure of existing social and communication roles • Impact of existing beliefs on using technology to change roles • Impact of existing beliefs on using technology to change role structures

Figure 1

Burt [4] described two basic issues addressed by SNA: boundaries and behaviors. The boundaries issue (Figure 1) addresses how individuals are clustered based on their patterns of relationships. This is perhaps the most familiar aspect of social structure. There are two major views or traditions of social network structure: relational and positional [5], [27]. In the relational view, people are clustered together based on the strength of their direct relationships with one another. This is also referred to as cohesion. For example, a collection of individuals coheres into a definable group based on every member interacting frequently and strongly with every other member, but much less so with others not part of the group. Boundaries emerge from relationships that are formed and not formed. The cohesion or relational approach uses measures of tie density, strength and flow among actors. It represents a useful approach to measure the effects of information technology on the flow of information or advice, on the social relations among users, and on the clusters that form organization structure. Conversely, it can be used to describe how the existing structure constrains the use of the technology. Are individuals now more or less central to the flow? Are units now more or

less permeable after implementing a technology? Are more people now in more direct contact? Measured over time, do the relations exhibit more or less dynamic flexibility and ability to adapt?

Generally, the relational approach suggests that organizational systems may affect the ability of people in the organization to connect and communicate with one another. This capability may range from direct communication via electronic mail or discussion databases to repositories for indirectly exchanging information using a “pull” or subscription service, to creating organizational “yellow pages” to facilitate finding others with similar interests or needed expertise [44]. The implication is that greater connectivity and communication will improve organizational performance. The technology may also affect the nature and distribution of existing links. For example, the ability to exchange task related information with a wider set of people may result in other relationships forming. And where face-to-face friendship relationships might have been a key driver of cross-functional ties, this may be augmented by a communication technology that enables creating new

forms of connection despite having no alternative existing relationship.

The existing set of relationships will also influence and constrain the impact of technology. Beliefs, if shared by a tight sub-community, may result in adoption or use patterns varying by sub-community. This may result in varying degrees of adoption across an organization such that not all the sub-communities needed for effective performance may be using the technology. Even widespread adoption of a technology it may be constrained to reinforcing existing patterns of interaction and work practice (e.g., [45]).

The positional approach clusters those who have similar patterns of relations with others, even if those people do not have direct relations with each other. A person's pattern of relations is called a role set [22]. All those playing a similar role are said to occupy similar structural or status positions. So, for example, in a legal system, judges would be clustered together, not because they interact with each other (although they may), but because they share similar patterns of interaction with

measuring the effects of organizational technologies on roles and status.

Generally, the positional approach suggests that the technology may affect the existing social and communication roles. For example, those who perform a gatekeeping role may find that role no longer necessary if people are given direct access to information that was formerly controlled by the gatekeeper. On the other hand, new intermediary roles often are needed. For example, discussion databases require moderators and facilitators. And again, the existing beliefs about the technology held by those in similar roles may influence the impact of the technology on those roles or the use of the technology by those inhabiting those roles.

Structuration theory [16] suggests that structure constrains process and that repeated process creates or adapts structure. The positional approach represents the existing structure that constrains action [5], while the relational approach represents the actual interactions which provide a means to define and redefine existing structure [6], [27].

	Behaviors: freedom to act		
Key concept	Prominence	Range	Brokerage
Based on:	Demand for relations with an individual actor	Weak ties to many parts of a large network	Holes in the network structure providing opportunities to broker connections
Key constructs:	Power Prestige Hierarchical status	Access (to resources and views)	Autonomy (extent of non-connected contacts)
Implications for Organizational Systems:	<ul style="list-style-type: none"> Impact of the technology on hierarchy and power structures Impact of the power structure on the use of the technology 	<ul style="list-style-type: none"> Impact of the technology on providing access to resources Impact of many dissimilar views on use of the technology 	<ul style="list-style-type: none"> Impact of the technology on the ability to coordinate or make markets for goods and information Impact of brokers on influencing the use of the technology

Figure 2

similar others such as lawyers, plaintiffs, defendants, bailiffs and clerks. That is, they share similar positions or roles. Positional analysis is useful in describing and

Boundaries influence beliefs [4]. The key concept is that of "contagion" - the pattern by which information, beliefs or behaviors are transferred and diffused through a

network. For example, consulting firms are interested in determining if new knowledge management technologies affect the way a new consulting method is diffused and adopted within their firms (e.g., [18]), compared to the traditional methods of formal training and ad hoc, informal interpersonal interaction. From a relational perspective, influence is applied through repeated interaction, leading to shared opinions among strongly connected individuals. From a positional perspective, shared views emerge from people playing similar roles.

Behaviors (Figure 2) addresses the freedom or power to act [4], and in the technology context may apply to behaviors ranging from adopting or using the technology itself, to the impact of the technology on related behaviors such as task performance or decision making. Network analysis addresses three aspects of power: Prominence, range and brokerage. Prominence reflects the hierarchical status of an individual. It measures the centrality of an individual or a network based on the demand for linking to a node - the degree to which ties are directed to one node at the expense of all others. If the intention of a technology is to flatten the organization, this metric provides a useful way to assess that impact. The existing hierarchy may also constrain the adoption or use of a technology and indicate those who may exert the most influence and must be coopted. Range reflects discretion to act. The greater the range of one's ties, the more resources and views one has access to, and the less dependent one is on particular ties. Organizational technology may provide far greater ability to locate and create access to resources and views. On the other hand, a diversity of views may influence the impact or use of the technology in more complex and difficult to manage ways. Finally, brokerage reflects the ability to exploit "holes" in a social network by connecting nodes that formerly have not been connected. By measuring the extent of holes in a knowledge-sharing network structure, for example, before and after implementing a knowledge management technology, it maybe possible to gauge the impact of the technology on enabling "knowledge exchange markets" in the organization. Brokerage metrics also provide a way to measure the impact of an organizational technology on coordination. Brokerage indicates not only opportunities to exploit the technology but points of resistance that may arise by those currently filling a brokerage role.

A dominant concept of social network analysis is that of centrality ([11], [12]). Actors are more central to the extent they have more relations with more members of the network (relational), play a role that is more connected to other roles (positional), are higher in the hierarchy (prominence), have a greater range of ties (range), and are more tied to non-connected others (brokerage). A network is more centralized to the extent the distribution of individual actor centrality is skewed towards a small number of individual members. If all members of a

network are well-connected (to one another), then the network is totally decentralized. Organizational information systems may affect centrality. Creating a "network" organization (although all organizations - even strict hierarchies - can be described as networks) is often a goal in implementing organizational systems, and is typically meant to imply a structure that exhibits a very low degree of centrality (i.e., a high degree of connectedness).

4. Some examples

While network analysis has been used extensively to study organizations, it has received small attention from the information technology field. I briefly review three examples of the small number of network-based studies.

Burkhardt and Brass [3] used social network analysis to examine the organizational impacts of a new information technology, specifically the relationship between centrality, power and the timing of adoption of a new distributed computing system. They reasoned that a new technology would increase uncertainty, raising the power of those able to mitigate that uncertainty, while increasing the need to communicate about that uncertainty and thus altering the social communication network. They found that early adopters increased their power and centrality to a greater degree than later adopters. They also observed changes in the network structure as a result of the new technology.

Rice and Aydin [33] used social network analysis to examine the mechanism by which individual attitudes toward an information system were influenced by the attitudes of socially proximate others. They identified three mechanisms for proximity: relational, positional and spatial. Relational and positional proximity were defined following the discussion above, while spatial proximity represented physical location. They found that attitudes towards an information system are socially influenced and that relational and positional proximity are greater influences than traditional occupational roles and spatial proximity.

Zack and McKenney [45] examined how existing social structure influences how an organization appropriates electronic messaging systems. By mapping the social networks and the computer-mediated communication (CMC) networks for each organization, they were able to make direct comparisons between networks and between organizations. By comparing both networks within organizations, they found that the CMC network closely reflected the social structure. Comparing networks across organizations, they found that where the social structure reflected open, collaborative communication and a participative management style, CMC was used to broaden the communication networks and make them more responsive. Where the social structure reflected conflicted relationships and a strict, centralized hierarchy, CMC was appropriated in a way

that reinforced the hierarchy. They were able to relate performance effectiveness to particular communication patterns to show why the technology enabled effective performance in some organizations while not in others. The key finding was the social structure influenced the way the technology was appropriated and therefore mediated its impact on organizational performance.

5. Conclusion

In a seminal study, Barley [1a] showed that the effects of a new technology are profoundly social, both as to how the existing social structure may constrain use of the new technology and how that technology may alter the social structure. The examples provided above applied to information technologies confirm this view. In the structuration sense, organizational systems both affect the social communication structures and are socially constrained by those structures. Performance effectiveness is mediated by those structures. Therefore an understanding of the interaction between information technology and social structure is required to fully understand the impact of organizational technologies. And if we are looking to understand the influence of organizational information systems on organizational form and structure, broadly defined to include patterns of communication and information flow, then social network analysis is the natural formalism. This is especially so for issues such as

- describing “network” organizations and the affect of information technology on them;
- measuring patterns of communication and how they are affected by information technology (either via communication technologies directly or by other technologies indirectly);
- measuring the impact of technologies on the fostering or modifying of relationships of various kinds.

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