MANAGING KNOWLEDGE NETWORKS

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The concept of Knowledge Management (KM) (Nonaka & Takeuchi, 1995) was popularized in the 1990s at a time when the dominant organizational metaphor was "organizations as computers." Consistent with that metaphor, KM was conceptualized as creating and maintaining a stand-alone repository for capturing organizational expertise. The explosion of the Internet and World Wide Web has made this view obsolete and transformed the metaphor into one of "organization as networks," leading one recent trade book to title a section, "It's the network, stupid!" (Hartman, Sifonis, & Kador, 2000). This reconceptualization from stand-alone repositories to knowledge networks implies that intelligence resides in the network as a whole rather than in particular nodes (Contractor, 2002). These knowledge networks contain the collective competencies that enable organizational members to produce products and services.

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CONCEPTUALIZING KNOWLEDGE NETWORKS

The nodes in a knowledge network include individuals as well as aggregates of individuals, such as groups, departments, organizations, and agencies. Increasingly, the nodes also include nonhuman agents such as knowledge repositories, Web sites, content and referral databases, avatars, and "webbots" (Carley, 2002). The social structures in these networks refer to who knows whom in the network, whereas the cognitive social structures refer to who knows who knows whom (Krackhardt, 1987). The knowledge network linkages describe who knows what, whereas the cognitive knowledge network linkages refer to who knows who knows what. The communication network linkages include knowledge retrieval from human and nonhuman agents as well as allocation of information to others. Other influential organizational networks' linkages include trust and authority relations, formal alliances, and proximity, as well as the relations specified by the underlying information technology infrastructure such as intranets and extranets. The challenge of KM is, therefore, reconceptualized as a challenge of understanding the psychological, social, and communicative mechanisms by which these knowledge networks ties are created, maintained, dissolved, or reconstituted.

THEORETICAL MECHANISMS FOR EMERGENCE OF KNOWLEDGE NETWORKS

Monge and Contractor (2001; in press) have proposed a multitheoretical, multilevel (MTML) model to study the management of knowledge networks. The primary question addressed by the MTML model is, What are the psychological, social, and communicative theoretical mechanisms that help us understand why individuals and aggregates forge, sustain, or dissolve knowledge network ties with other human and nonhuman agents? The MTML model argues that no single theory can account for the complex

motivations that inform our decisions to forge, maintain, or dissolve knowledge network ties. Instead, there are multiple theoretical mechanisms operating simultaneously, sometimes reinforcing and in other cases undermining one another. For instance, based on mechanisms suggested by theories of homophily, individuals forge "birds of a feather" knowledge network ties with others who may share similar attributes such as gender or level in the hierarchy. However, this motivation may be undermined by mechanisms suggested by cognitive theories whereby one might seek out an expert even if that person does not share any attributes. Hence, these multiple theoretical mechanisms, enumerated later in this section, must be examined systemically.

The MTML model also argues that the multiple theoretical motivations for developing knowledge network ties operate at multiple levels, including individual links, dyads, triads, cliques, and at the global level of the entire network. For instance, theories of social exchange suggest that an individual will seek a knowledge network tie with another individual if the other can reciprocate and offer something in return. As such, this mechanism operates at the dyadic level. However, theories of mutual interest suggest that an individual will contribute to a knowledge repository only if all other members in the network are also willing to do so. Hence, this motivation can only be explained by examining, at the global level, the entire network.

Monge and Contractor (in press) identified a wide array of social and communication theories that explain the forging of knowledge network linkages. Theories of self-interest focus on how people make choices that favor their personal preferences and desires by creating ties that enable them to seek goals they wish to achieve. Two primary theories in this area are the theory of social capital (Burt, 1992) and transaction cost economics (Williamson, 1991). Theories of mutual interest and collective action examine how forging knowledge network ties produces collective outcomes unattainable by individual action. People create knowledge ties because they believe they serve their mutual interest in accomplishing common or complementary goals. Public goods theory (Fulk, Flanagin, Kalman, Monge, & Ryan, 1996) exemplifies this per-

spective by examining the conditions that induce network members to contribute their knowledge resources to the realization of public goods, such as databases or knowledge repositories.

Contagion theories address questions pertaining to the spread of ideas, messages, attitudes, and beliefs through direct or indirect network contact (Burt, 1987). Similarly, the spread of knowledge is blocked by isolating parts of the network or by inoculating against infection. Cognitive theories explore the role that meaning, knowledge, and perceptions play in network development. Decisions to forge network ties with others are influenced by who or what people think others know. Transactive memory systems (Moreland, 1999) consist of knowledge networks in which people assume responsibility for mastery among various aspects of larger knowledge domains. In this way, the collective is more knowledgeable than any component.

Exchange and dependency theories explain the emergence of knowledge networks on the basis of the distribution of information and material resources among network members (Cook, 1982). People seek the knowledge they need from others while giving what others also seek. Homophily and proximity theories account for emergence of knowledge networks on the basis of trait similarity as well as similarity of place (McPherson & Smith-Lovin, 1987). Here, knowledge network ties are created on the basis of common traits such as age, gender, tenure, place, and professional interests. The theory of electronic propinquity extends this idea to the realm of e-mail, telephones, and other forms of electronic communication (Rice & Aydin, 1991).

Finally, coevolutionary theory posits that linkages are typically created in the belief that they will increase individual or organizational fitness, measured as performance, survivability, adaptability, robustness, and so on (Campbell, 1986). Coevolutionary theory articulates how communities of organizational populations linked by intrapopulation and interpopulation knowledge networks compete and cooperate with each other for scare resources (Baum, 1999; Monge & Contractor, in press). Creation and maintenance of community networks is key to collective survival.

EMPIRICAL FINDINGS ABOUT THE EMERGENCE OF KNOWLEDGE NETWORKS

Preliminary findings from our research (Contractor et al., 1998) indicate that three theoretical mechanisms are particularly influential in explaining the creation of network ties for retrieval and allocation of information among individuals. They are, specifically, transactive memory theory, social exchange, and proximity. That is, individuals tend to retrieve information from those who they think are knowledgeable; they also tend to retrieve information from those to whom they can offer expertise in another area in exchange, and, finally, they seek information from others who are in close proximity, irrespective of whether they may be considered an expert. Furthermore, individuals tend to be more, not less, likely to retrieve information directly from those who publish to knowledge repositories. This finding runs counter to the argument that publishing to a common database reduces the need for others to retrieve information directly from the publisher. Our preliminary results suggest that publishing serves more as a signal about which individuals are knowledgeable in certain areas—which then leads others to contact them directly.

Our research also provides preliminary insights about the MTML mechanisms that explain motivations to publish and retrieve knowledge from repositories. First, public goods theory explained that individuals created and sustained publishing and retrieval links with knowledge repositories if they perceived that the repository had a high provision of collective knowledge contributed by the group in an area of interest to them, and if the costs of accessing the repository were low. Second, as suggested by cognitive theory, the links between individuals and knowledge repositories were sustained if people believed that knowledgeable others in the network were contributing to the database. Finally, there was only modest evidence of social exchange mechanisms in that retrieving information from a knowledge repository did not increase the likelihood that people would publish to it.

Taken together, the theoretical analysis and empirical findings offer interesting insights about the MTML factors that influence

the creation and maintenance of knowledge networks. Additional research from this framework will suggest how to design novel technological infrastructures to support knowledge networks.

DESIGNING KNOWLEDGE NETWORKS FOR THE FUTURE

The managing-knowledge-networks approach developed in this essay is increasingly salient as we leverage many emerging technological capabilities, including "communityware" and peer-to-peer (P2P) infrastructures. These emerging technologies are in contrast to traditional server-client infrastructures, where one or more of the nonhuman agents is the server and the individuals who publish or retrieve information are clients. Although this infrastructure dominates most of what we encounter today on the Web, intranets, and extranets, it is being challenged by new technological infrastructures. As we argue below, the social implications of these new infrastructures further underscore the need for an MTML framework.

Communityware programs help individuals identify who knows what (Wellman, 2001) based on the premise that retrieving a document in a particular knowledge area is often less useful than contacting a knowledgeable person. This capability is heightened when the knowledge desired is not easily "migrated" via a document, and hence, interaction with the expert is crucial to gain access to the embedded knowledge. Communityware can be considered as a referral rather than a content database, an example of which is IKNOW (Inquiring Knowledge Networks on the Web) (Contractor, O'Keefe, & Jones, 1997). It has the potential to reorganize communities by visually making explicit to its members the following relationships: Who knows whom? Who knows what? Who knows who knows whom? and Who knows who knows what? (Contractor & Bishop, 2000; Contractor, Zink, & Chan, 1998). The MTML model is particularly well suited to examine the impacts of communityware programs on the evolution of knowledge networks. By making visible to individuals in the community the identities of others that have shared or complementary expertise, all individuals can have the ability to accurately identify the nodes that have the exper-

tise they seek to obtain. By equalizing their cognitive knowledge networks, communityware programs explicitly invite an examination of the other theoretical mechanisms that might motivate individuals to seek knowledge from one node rather than another. That is, the MTML model offers an analytic framework to explain why person *X* might forge a knowledge network link with person *Y* despite person *X*'s awareness (from communityware programs) that person *Z* is the leading expert on a particular topic of interest.

A peer-to-peer (P2P) infrastructure (Contractor, in press; Oram, 2001) creates a network in which each node is both a server and a client (sometimes called a servent). Examples of this architecture include the well-known web sites Napster and eBay, where central knowledge repositories are replaced by connecting individuals directly to one another. Other P2P applications, such as Gnutella, Morpheus, FreeNet, and Groove, dispense with intermediary directory servers, using instead automated search algorithms to help peers determine who has what or who knows what within the network. The MTML model is especially appropriate to study the emergence of knowledge networks based on P2P infrastructures. In a server-client infrastructure, our research and theory focused on explaining why each of the client nodes connected to one or a few server nodes. But as we migrate to P2P infrastructures, theory and research need to examine the multiple theoretical motivations that explain why each node may choose to connect with any of the myriad other nodes in the network.

CONCLUSION

The future of knowledge network theory and research is nothing if not highly promising. We have come to realize that we live in a highly connected, knowledge-intensive, organizational world, where the structural interconnections in large part determine what we know and what we can and cannot do (Castells, 1996). Concurrently, the amount of knowledge network theorizing and research has grown geometrically in the past 15 years. Furthermore, this explosion of work has crossed many disciplines (Monge & Contractor, in press). Never before has the opportunity or necessity to

manage knowledge networks been as great as it is today. To make significant progress in our efforts to understand how best to manage knowledge networks, we need to utilize MTML models to integrate multiple social and communication theories at multiple levels of empirical analysis.

REFERENCES

Baum, J. A. C. (1999). Whole-part coevolutionary competition in organizations. In J. A. C. Baum & B. McKelvey (Eds.), *Variations in organization science: In honor of Donald T. Campbell* (pp. 113-135). Thousand Oaks, CA: Sage.

Burt, R. S. (1987). Social contagion and innovation: Cohesion versus structural equivalence. *American Journal of Sociology*, *92*, 1287-1335.

Burt, R. S. (1992). *Structural holes: The social structure of competition*. Cambridge, MA: Harvard University Press.

Campbell, D. T. (1986). An organizational interpretation of evolution. In D. D. Depew & B. H. Weber (Eds.), *Evolution at a crossroads: The new biology and the new philosophy of science* (pp. 133-167). Cambridge, MA: MIT Press.

Carley, K. (2002). Smart agents and organizations of the future. In L. Lievrouw & S. Livingstone (Eds.), *Handbook of new media* (pp. 206-220). London: Sage.

Castells, M. (1996). *The rise of the network society: Vol. I. The information age: Economy, society and culture*. Oxford, UK: Blackwell.

Contractor, N. S. (2002). Introduction: New media and organizing. In L. Lievrouw & S. Livingstone (Eds.), *Handbook of new media* (pp. 201-205). London: Sage.

Contractor, N. (in press). Peer to peer. In S. Jones (Ed.), *Encyclopedia of new media*. Thousand Oaks, CA: Sage.

Contractor, N., & Bishop, A. P. (2000). Reconfiguring community networks: The case of PrairieKNOW. In T. Ishida (Ed.), *Digital cities: Technologies, experiences, and future perspectives. Lecture notes in computer science* (pp. 151-164). Berlin, Germany: Springer-Verlag.

Contractor, N. S., Carley, K., Levitt, R., Monge, P., Wasserman, S., Bar, F., et al. (1998). *Co-evolution of knowledge networks and twenty-first century forms: Computational modeling and empirical testing*. Research proposal funded by the National Science Foundation (Grant # IIS-9980109).

Contractor, N. S., O'Keefe, B. J., & Jones, P. M. (1997). *IKNOW: Inquiring knowledge networks on the Web* [Computer software]. University of Illinois at Urbana-Champaign: http://iknow.spcomm.uiuc.edu

Contractor N., Zink, D., & Chan, M. (1998). IKNOW: A tool to assist and study the creation, maintenance, and dissolution of knowledge networks. In T. Ishida (Ed.), *Community computing and support systems: Lecture notes in computer science* (pp. 201-217). Berlin, Germany: Springer-Verlag.

Cook, K. S. (1982). Network structures from an exchange perspective. In P. V. Marsden & N. Lin (Eds.), *Social structure and network analysis* (pp. 177-218). Beverly Hills, CA: Sage.

Fulk, J., Flanagin, A. J., Kalman, M. E., Monge, P. R., & Ryan, T. (1996). Connective and communal public goods in interactive communication systems. *Communication Theory*, *6*, 60-87.

Hartman, A., Sifonis, J., & Kador, J. (2000). *Net ready: Strategies for success in the e-conomy*. New York: McGraw Hill.

Krackhardt, D. (1987). Cognitive social structures. *Social Networks*, *9*, 109-134.

McPherson, J. M., & Smith-Lovin, L. (1987). Homophily in voluntary organizations: Status distance and the composition of face to face groups. *American Sociological Review*, *52*, 370-379.

Monge, P. R., & Contractor, N. S. (2001). Emergence of communication networks. In F. Jablin & L. L. Putnam (Eds.), *The new handbook of organizational communication* (pp. 440-502). Thousand Oaks, CA: Sage.

Monge, P. R., & Contractor, N. (in press). *Theories of communication networks*. New York: Oxford University Press.

Moreland, R. L. (1999). Transactive memory: Learning who knows what in work groups and organizations. In L. Thompson, D. Messick, & J. Levine (Eds.), *Sharing knowledge in organizations* (pp. 3-31). Mahwah, NJ: Lawrence Erlbaum.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. New York: Oxford University Press.

Oram, A. (Ed.). (2001). *Peer-to-peer: Harnessing the power of disruptive technologies*. Sebastopol, CA: O'Reilly & Associates.

Rice, R. E., & Aydin, C. (1991). Attitudes toward new organizational technology: Network proximity as a mechanism for social information processing. *Administrative Science Quarterly*, *9*, 219-244.

Wellman, B. (2001). Computer networks as social networks. *Science*, *293*, 2031-2034.

Williamson, O. E. (1991). Comparative economic organization: The analysis of discrete structural alternatives. *Administrative Science Quarterly*, *36*, 269-296.

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