JOURNAL OF COMPUTER-MEDIATED COMMUNICATION

Special Section

The Emergence of Multidimensional Networks

Noshir Contractor

Northwestern University, Kellogg School of Management, Industrial Engineering & Management Sciences, and Communication Studies

doi:10.1111/j.1083-6101.2009.01465.x

Recent advances in digital technologies invite consideration of organizing as a process that is accomplished by global, flexible, adaptive, and ad hoc networks that can be created, maintained, dissolved, and reconstituted with remarkable alacrity. We are all familiar with the conundrum facing information technology professionals and knowledge network practitioners in communities. Despite our best efforts to design technologies to support the creation and sharing of knowledge via point-to-point channels or databases, these technologies often remain largely underutilized. The "If we build it, they will come" adage has little currency in the design, deployment, and adoption of the vast majority of technologies. Yet there are some success stories that suggest the need to understand the social factors that shape the use of technologies to create and sustain organizational, interorganizational, and community knowledge networks. Indeed, as developments in information and communication technologies continue to reduce or eliminate the potential *logistic* barriers to our communication and knowledge networks, it becomes increasingly important to identify the various *social* factors that enable or constrain the development of these network linkages.

This essay outlines four recent developments that serve as an intellectual springboard to significantly advance our ability to understand and enable these multidimensional networks.

Advances in theorizing the social motivations for emergence of multidimensional networks

Over the past 2 decades, social scientists have developed and tested theories about the social motivations for creating, maintaining, dissolving, and recreating social and knowledge network ties among individuals (see Contractor, Wasserman & Faust, 2006 for an overview). However, recent developments in Web 2.0, the Semantic

Web (Shadbolt, Hall, & Berners-Lee, 2005) and Cyberinfrastructure (Atkins, 2003; Contractor, 2005) underscore the need to theorize about the emergence of linkages in "multidimensional networks"—where the nodes are people as well as "nonhuman agents" such as documents, datasets, analytic tools, and concepts (or keywords) (Hollingshead & Contractor, 2002). The links among these nodes would include, for instance, *people* accessing/creating/citing *documents*, *documents* that report results based on a *dataset*, *analytic tools* used to investigate a *dataset*, *keywords* associated with certain *documents*, and so on.

In pragmatic terms, we need to build a theoretical foundation to address questions such as "Why is it that in some cases we seek information from other individuals while in other instances we go to a nonhuman agent such as a database? When do we go to a person to get suggestions about which nonhuman agent to access? When do we go to a non-human agent to identify the person we should contact? To what extent does the creation of common knowledge repositories substitute or augment direct communication between individuals or organizations?"

In intellectual terms, we ask the question: What are the social motivations that help us understand why we as individuals seek to forge, sustain, or dissolve our knowledge network ties with other human and nonhuman agents? Theorizing the emergence of these multidimensional networks should leverage several intellectual and methodological streams of ongoing research including social network theory (Monge & Contractor, 2003), network society (Castells, 2001) and actor-network theory (Latour, 2005).

Development of cyberinfrastructure/Web 2.0 to capture vast amounts of relational metadata

The capturing of massive amounts of digitalized information about human behavior (especially relational behavior) and the capacity to manipulate those data provides an unprecedented opportunity for new insights into collective human behavior (Contractor et al., 2007). The Web 2.0, Semantic web, and cyberinfrastructure technologies that have enabled the multidimensional networks described above also provide the opportunity to capture, tag, and manifest high-resolution high-fidelity relational "metadata" (i.e., which node is connected to which other node) from these multidimensional networks. These include (i) technologies that "***capture***" communities' relational metadata (Pingback and trackback in interblog networks, blogrolls, digital traces, data provenance), (ii) technologies to "***tag***" communities' relational metadata (ranging from Dublin Core taxonomies to folksonomies ('wisdom of crowds') like tagging pictures (Flickr), social bookmarking (del.icio.us, digg. reddit, LookupThis, BlinkList), social citations (CiteULike.org), social libraries (discogs.com, LibraryThing.com), social shopping (SwagRoll, Kaboodle, thethingsiwant.com), and social networks (FOAF, XFN, MySpace, Facebook), and (iii) technologies to "***manifest***" communities' relational metadata (Tagclouds, Recommender systems, Rating/Reputation systems, ISI's HistCite and CiteMap to visualize multidimensional

networks. As a result, in addition to serving as a means of communication and collaboration, the Internet is the world's largest social science observatory.

Opportunity for design-assisted theory construction

The current activities surrounding the development of Web 2.0, the Semantic Web, and Cyberinfrastructure also create an unprecedented potential for the development of "design-assisted theory construction" to advance our understanding of communication technologies and social behavior. Recent scholarship (Bar & Sandvig, 2008; Lessig, 2006) has documented how software code embedded in technologies has substantial influence on the structuring of society and social interactions. Their efforts underscore the extent to which "code" once in place might enable and constrain future activities. But a priori "code" is not necessarily a bug–it could be a feature (pun intended). We have the ability to design new technological features not as an end in itself but a means towards an end–theory construction. Not unlike the design of laboratory experiments, we have the opportunity to embed in the "design code" of technologies various theoretical mechanisms and systematically observe the manner in which these mechanisms interplay with social behaviors. As such virtual worlds, virtual communities, and virtual organizations become an exploratorium for us to implement and observe the effect of specific sociotechnical interventions on the emergence of multidimensional networks (Contractor et al., 2008). For many years, firms such as Amazon.com have been strategically deploying various "experimental manipulations" to better understand human purchasing behavior. Indeed, Dr. Andreas Weigend, a former Chief Scientist, described Amazon.com as the world's largest social science laboratory! Virtual worlds such as Second Life are especially well-suited to such "design-assisted theory construction."

Advances in confirmatory network analysis to empirically test structural signatures in multidimensional networks

Recent advances in the development of statistical techniques such as Exponential Random Graph Modeling (also known as p^*) in social network analysis have created the opportunity for a new generation of "confirmatory network analysis" - to empirically test cross-sectional and longitudinal hypotheses about the extent to which multiple theoretical motivations, operating at multiple levels of analysis, contribute to the emergence an observed multidimensional network (Robins et al., 2007). These techniques, have the potential to serve as the equivalent of a "statistical network MRI" to unravel the theoretically grounded structural signatures that contribute to the observed multidimensional networks.

Conclusion

In summary, spurred by recent advances in Web 2.0, the Semantic Web, and Cyberinfrastructure, there is a pressing societal need to understand the social

motivations for emergence of multidimensional social and knowledge networks. The research on the dynamics of these networks is well poised to make a quantum intellectual leap by facilitating transdisciplinary collaboration among:

- Social scientists that leverages recent advances in heretofore disparate areas such as social network theories and actor network theory
- Social scientists and design scholars that enable the development of design-assisted theory construction.
- Social scientists and computer scientists that enable harvesting of the vast amount of relational metadata generated by Web 2.0/Cyberinfrastructure
- Social theorists and methodologists that enable the use of recent advances in confirmatory network analytic techniques to test hypotheses that will advance our understanding of how we are constrained and enabled by the multidimensional networks in which we are embedded.

References

Atkins, Daniel (2003). *Revolutionizing science and engineering through cyberinfrastructure*: Report of the National Science Foundation Blue-Ribbon Advisory Panel on Cyberinfrastructure.

Bar, F., & Sandvig, C. (2008). US communication policy after convergence. *Media Culture & Society*, **30**(4), 531–550.

Castells, Manuel (2001). *The Internet galaxy: Reflections on the Internet, business and society*. Oxford: Oxford University Press.

Contractor, N (March, 2005). *The role of social network analysis in enabling cyberinfrastructure and the role of cyberinfrastructure in enabling social network analysis.* White paper prepared for the National Science Foundation workshop on Cyberinfrastructure for the Social Sciences, Airlie House, Warrington, Virginia, USA.

Contractor, N., Wasserman, S., & Faust, K. (2006). Testing multi-theoretical multilevel hypotheses about organizational networks: An analytic framework and empirical example. *Academy of Management Review*, **31**, 681–703.

Contractor, N., Amaral, L., Monge, P. R., & Uzzi, B. (2008). *Understanding and enabling network dynamics in virtual communities*: *A Project funded by the National Science Foundation*. Technical Report.

Contractor, N., Poole, M. S., Srivastava, J., & Williams, D. (2007). *Virtual worlds: An exploratorium for theorizing and modeling the dynamics of group behavior*: *A project funded by the National Science Foundation*. Technical Report.

Hollingshead, A.B., & Contractor, N. (2002). New media and organizing at the group level. In L. Lievrouw & S. Livingstone (eds.), *The handbook of new media* (pp. 221–235). Thousand Oaks, CA: Sage.

Lessig, L. (2006). *Code v2, and other laws of cyberspace*. New York: Basic Books.

Monge, P. R., & Contractor, N. S. (2003). *Theories of communication networks*. New York: Oxford University Press.

Shadbolt, N., Hall, W., Berners-Lee, T. (2006). "The semantic web revisited". IEEE Intelligent Systems. 96–101.

Author Biography

Noshir Contractor is the Jane S. & William J. White Professor of Behavioral Sciences in Communication Studies, Industrial Engineering & Management Sciences, and at the Kellogg School of Management at Northwestern University. He is the Director of the Science of Networks in Communities (SONIC) Research Group.

He is investigating factors that lead to the formation, maintenance, and dissolution of dynamically linked social and knowledge networks in communities. Specifically, his research team is developing and testing theories and methods of network science to map, understand, and enable more effective (i) disaster response networks, (ii) public health networks, (iii) transnational immigrant networks, (iv) massively multiplayer online games (MMOs) networks, and (v) environmental engineering networks. His research program has been funded continuously for the past decade by major grants from the U.S. National Science Foundation.

Professor Contractor has published or presented over 250 research papers dealing with communication. His book titled *Theories of Communication Networks* (coauthored with Professor Peter Monge and published by Oxford University Press) received the 2003 Book of the Year award from the Organizational Communication Division of the National Communication Association. He is the lead developer of *IKNOW* (Inquiring Knowledge Networks On the Web), and its Cyberinfrastructure extension *CI-KNOW*, a network recommender system to enable communities using cyberinfrastructure, as well as *Blanche*, a software environment to simulate the dynamics of social networks.