NETWORKS AND COMMUNICATION

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Rice, R.E. (2001).

Network analysis is the study and interpretation of influences on, forms of, and outcomes from, patterns of relations among entities. The overall structure of a network, the relationships among the network members, and the location of a member within the network, are critical factors in understanding social behavior. They influence, among other things, access to resources, the distribution of social and organizational power, the spread of new ideas as well as diseases, career success and mobility, workplace diversity, job satisfaction, and even personal health and longevity.

The network approach has been applied to studying a wide range of topics, such as referrals among community helping agencies, overlaps in company boards of directors as part of antitrust investigations, changes in friendship among elementary school students, rumor diffusion in organizations, interactions among transients and regular patrons at late-night diners, citation patterns among members of scientific disciplines, the role of formal organizational communication networks compared to emerging informal networks, the structure of international telecommunication traffic, and contributions to nonprofit agencies. Georg Simmel's 1908 *The Web of Group Affiliations*, and Jacob Moreno's 1934 *Who Shall Survive?* were some of the first books to describe and apply this approach. Other early studies considered kinship networks in tribal villages, relational patterns among families, interactions among workers in manufacturing or mining sites, and the development of class and group identity through joint attendance at social events.

Network Data, Measures, and Analysis

Network data are fundamentally different from the typical social science approach, which

collects information about a variety of variables (such as demographics, attitudes, performance) from a (ideally) random set of individuals (such as students, managers, organizations). This approach assumes that the individuals are independent, so the topic of interest is the association among variables. Typical data are thus a "people by variable" matrix.

For network analysis, the data consists of the relationships among the entities. The entities may be people, organizations, words, events, and so on. The relations may be communication, trade, co-occurrences, hierarchies, or the like (though the rest of this entry will refer to "people"). The strength of such relations among the people might be measured by such things as frequency, attraction, length, and dependency. This is thus a "people by people" dataset. The relations among people might be identified by observation, surveys, archival data, information-system-collected data, transcribed conversations, or analysis of printed material, diaries, legal records, and so on. For example, an organizational study might use a survey that has a section listing all the members of the organizational department, which asks respondents to indicate how frequently they communicate with other members of that department. Note, however, that network data are usually collected along with variable data, and often analyzed together. Further, a "people by variable" matrix can be converted into a "people by people" matrix.

Data about these relationships can be collected at, and analyzed by, several levels of analysis. The most basic levels are the individual and the network level.

Data collected at the individual or "ego" level involves measures of the relations in general of a set of individuals or their relations to specific others, without knowledge of the complete network of relations among all the others. These might include the number of friends a person has at school; the number of times a manager asked for advice from, or gave advice to, coworkers; or the number of suppliers an organization uses. Analyzing such individual-level data would allow researchers to differentiate the people as being more or less popular, seekers or givers of advice, or more or less dependent. The network level of analysis would describe or compare groups of people (say, part-time and full-time employees) on such individual-level measures.

Data collected at the network level involves measuring relations among all the members of a particular network (a group, an organizational department, an academic discipline, an industry). This allows analysis of the interdependencies among the members, including indirect relations and both presence and absence of relations. Such analysis can characterize individuals' network properties, including the in-degrees (the number of links a person receives from others), out-degrees (the number of links a person gives to others), density (percentage of all possible links each person has), centrality (the extent to which the person is close to or is part of all other relations in the network), integrativeness (the extent to which a person's direct relations are also related), power/prestige (the extent to which a person receives relations from others who are also powerful), reciprocity (the proportion of relations that flow both to and from a person), and roles or positions.

Typical organizational communication network roles include being a member of a group (or "clique"), the liaison (who connects groups but is not a member of any group), the bridge (who belongs to one group but provides a direct link to another group; this may include the "gatekeeper"), the isolate (who does not belong to any particular group), the opinion leader (to whom others turn for leadership and legitimization of group norms), and the boundary spanner, environmental scanner, or cosmopolite (who provides a link between the organization and the environment). Other roles include the broker (who passes information or resources along), a follower (who provides links to but not from others), a leader (who receives links from but may not provide links to other), and people who occupy similar positions (who are "equivalent" even though they may not have direct relationships among themselves).

Such analysis can also characterize network properties of dyads (such as reciprocity and similarity in the network) or triads (such as transitiveness, the extent to which a relation between entity A and B and a relation between B and C also involves a relation between C and A). Finally, network-level analysis can characterize properties of the network as a whole, such as overall density, centrality, integrativeness, power/prestige, reciprocity, transitiveness, and other measures of structure. However, network-level analysis can also provide a wide array of network-level por-

trayals, such as separate and overlapping cliques within the network, positions within the network that include people that are similar to each other with respect to their relations to all other entities, multidimensional visual portrayals of the relations among the entities within the whole or portions of the network, or clusters of people that are grouped together in hierarchical fashion depending on the strength of the relation.

To summarize, then, researchers can collect network data at the individual or network level. They can then analyze individual-level network data at the individual level, or describe and compare that individual-level network data within different groups. Or researchers can collect network data at the network level, and then analyze that data to produce individual-level or network-level measures and results. Finally, they can analyze the combined individual- and network-level measures. Further, researchers can collect any of these kinds of data across time, to compare individuals and networks longitudinally. For example, studies have shown that organizational mergers often fail because the work networks of the two companies do not become more densely connected over time, or the network of the acquiring company remains centralized. Or, the use of electronic mail allows organizational members to overcome physical, temporal, and hierarchical obstacles and thus participate in more decentralized communication networks over time. Researchers can also collect and combine data from several networks, such as within an organization, formal and informal work relations, interdependence among tasks, sources of resources, and power relations, and test their relative influence, interaction, or change over time.

Developments and Debates

Network analysis has typically been used to study relations among individuals or organizations, but, as noted above, the possible applications are endless. One specific application is semantic network analysis, where text is analyzed to determine some measure of the extent to which words are related (such as how frequently words co-occur) within a given meaning unit (such as paragraphs in organizational documents). Then, this word-by-word network of relations is analyzed to produce measures for or clusters of the words. These results can be directly interpreted, used in other analyses, or compared between different groups, such as types of organizations, or a single organization before and after a major change.

A primary enduring theoretical issue involves the relative influence of "structure" (location of the individual in the network, and overall network characteristics) and "agency" (individual attributes and behaviors). An extreme structuralist would argue that almost all individual attitudes and behaviors are heavily constrained by the networks in which one is embedded. Extreme agency argues, in turn, that individuals shape the form and nature of their relationships and the resulting networks. More-integrated approaches attempt to understand the relative influences of individual and network factors on particular social phenomena, and, in turn, their effects on individual and network factors. Networks both constrain and facilitate social action, and, in turn, are constrained and facilitated by social action. Thus, one can study both the effect of preexisting networks and what affects the development and emergence of new network structures. Typically, then, network research would measure both individual and network attributes across time periods, and test one or more theoretical models as to the relative influence and causality of structure and agency.

An application of this debate in an organizational setting is the analysis of the extent to which members use a new communication medium, such as the Internet, because of task/individual factors (such as simplifying the work to be done) or because of social/structural influences (such as a manager expresses the opinion that the medium should be used or a coworker demonstrates extensive use of the medium). Network analysis provides both theory and measures to test the relative role of individual versus social influences. For example, a traditional study would measure each individual's usage of, attitudes toward, and outcomes from, electronic mail, as well as individual attributes such as demographics, type of task, prior experience, personality traits, and so on. A network study would also measure the extent to which all members of a department communicate with each other about work in general, and the new medium in particular, and other structural measures such as location in the organizational hierarchy, from which network measures would be computed. By combining these two kinds of data, analysis could then show how individual

and network factors interact to explain each individual's assessment of the new medium. These kinds of studies have shown that such network influence as exists is predominantly from coworkers (though also from managers when that person is a role model or opinion leader), is more likely if the medium is perceived as highly innovative or uncertain, and is stronger early on in the process, giving way to more individual-level influences such as task demands, perceived benefits, access and ease of use.

Another central theoretical and empirical debate centers around the distinction between cohesion and position. Cohesion approaches presume that direct relations among entities best represent network influences. Cohesion measures include in- and out-degrees, reciprocity, and cliques of densely interconnected members. So, for example, diffusion of an innovation would be best explained by patterns of direct and multistep communication between an early adopter and later adopters. Position approaches presume, instead, that what is more important than direct relations is the extent to which people occupy the same, or even similar, positions in the network. Position measures include the similarity of present and absent relations (as well as similarity of the relationships among the relations of an entity) throughout the network, such as correlations, closeness in multidimensional space, clusters, factor loadings, and various measures of equivalence. So, for example, here diffusion would best be explained by initial adoption by members of one's own position, even if those members do not communicate directly with each other, or by members attempting to emulate the adoption behavior of an influential position (such as "managers," not necessarily one's own manager). There are theoretical arguments supporting each approach, and many studies attempt to test the relative influence of cohesion versus position conceptualizations of networks. As with the structure and agency debate, studies often find that both approaches provide somewhat different contributions to explaining social behavior and attitudes.

Resources

Simple network analysis (such as drawing "sociograms" that show the relations among entities and computing some individual-level measures such as in- or out-degrees) can be done by hand. Somewhat more complex or large-scale networks can be analyzed through standard statistical software. However, it is more typical that proper processing of the data and analyses will require specific network analysis software. Perhaps the most widely used software of this type is UCINET (originally used at the University of California, Irvine).

See also: COMMUNITY NETWORKS; INTERNET AND THE WORLD WIDE WEB; ORGANIZATIONAL COMMUNICATION; RELATIONSHIPS, TYPES OF; RESEARCH METHODS IN INFORMATION STUDIES.

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