AN INTRODUCTION TO SOCIAL NETWORK THEORY

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Social network analysis (SNA) is currently popular. As shown in Figure 1, academic publications referencing "social networks" have been increasing exponentially over time. The interest in networks spans all of the social sciences, and is rising even faster in physics, epidemiology and biology. In management research (our field), social networks have been used to understand job performance (Sparrowe, Liden, Wayne and Kraimer 2001), turnover (Kilduff and Krackhardt 1994; Krackhardt and Porter 1985, 1986), promotion (Burt 1992), innovation (Obstfeld 2005), creativity (Burt 2004), and unethical behavior (Brass, Butterfield, and Skaggs 1998). In management consulting, network analysis and "networking" are fast becoming standard diagnostic and prescriptive tools (e.g., Anklam 2007; Baker 2000; Bonabeau and Krebs 2002; Cross, Parker and Borgatti 2000).

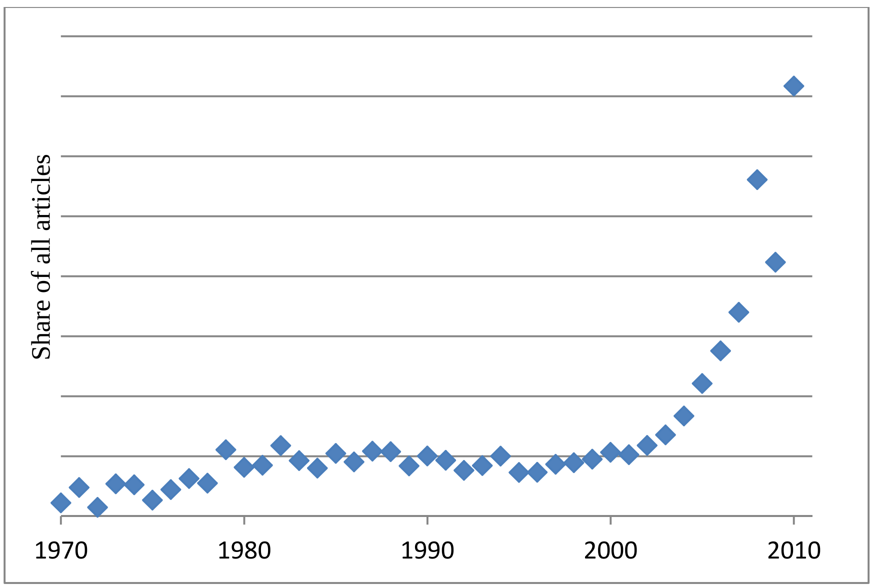


Figure 1. Share of all articles indexed in Google Scholar with "social network" in the title, by year, 1970 - 2011.

Despite this popularity (and, perhaps, in part because of it) there exists considerable confusion about social network analysis. Even though certain network theories are extremely well known – Granovetter's (1973) Strength of Weak Ties theory has been cited nearly 20,000 times[1] – it is not unusual to read that network analysis contains no theory of its own (Salancik 1995). In this view, SNA is "just" a

[1] Source: Google Scholar

methodology, and what theory there is, “belongs to” other fields, such as social psychology. Other misconceptions include references to network analysis as the “new science” (Barabasi 2002, Kocarev 2010), which fail to recognize the foundational influences of graph theory, sociometry, sociology and anthropology (e.g., Barnes 1954; Bott 1928; Harary Norman & Cartwright 1965; Moreno 1934; White 1963). Moreover, as the term “social network” gains caché, it is increasingly applied to everything from a trade association to a listserv to social media websites such as Facebook and Twitter.

Our objective in this paper is to clarify the concept of social network, and to begin to identify the characteristic elements of social network theorizing. We have a particular interest in explicating the mechanisms used in network theory so as to facilitate the generation of new theory and clarify best practices. In characterizing network theory, it is important to emphasize that our objective is not to define what should and should not be network theory. We do elaborate a view of what constitutes the heart of network theorizing, but it is worth remembering that the network analysis research program (in the sense of Lakatos 1980) is a social enterprise that includes all kinds of different researchers with different aims and backgrounds. There is a great deal of work that is part of the broader SNA research program that does not include the canonical elements we describe, or which includes additional elements that are not distinctive to the field.

What is a network?

A network consists of a set of nodes (sometimes called actors) along with a set of ties of specified type (such as friendship) that link them. In social network analysis literature, nodes are often individuals or collectives of individuals (e.g., corporate boards, families, organizations, nations)[2]. The ties interconnect through shared endpoints to form paths that indirectly link nodes that are not directly tied. The pattern of ties in a network yields a particular structure, and nodes occupy positions within this structure. Much of the theoretical wealth of network analysis consists of characterizing network structures (e.g., small worldness) and node positions (e.g., centrality) and relating these to group and node outcomes.

[2] Scholars have also used networks to investigate relationships among animals. In the physics literature, network analysis has been used to study links connecting websites.

It is important to realize that it is the researcher – by choosing a set of (and type of) nodes and a type of tie – that defines a network. A network is different from a group. A fundamental part of the concept of group is the existence of boundaries. Even while we recognize that boundaries may be fuzzy or uncertain (e.g., there are part-time members, "wannabees", conflicting views of what the group is, etc), the distinction between insiders and outsiders is an important part of the group concept. Therefore, when studying groups, we are justifiably concerned with establishing the boundaries of the group. For example, if we are studying gangs in Los Angeles, we would approach the boundary specification problem in an emic[3] way, such as interviewing insiders to determine natural group fault lines.

In contrast to groups, networks do not have "natural" boundaries (although, of course, we are free to study natural groups, in which case the group boundaries determine our nodes).[4] Networks also don't have to be connected. A disconnected network is one in which some nodes cannot reach certain others by any path, meaning that the network is divided into fragments known as components (see Figure 2). For those confusing networks with groups, this may seem an odd conceptualization of networks. The advantage, however, is that it facilitates the study of network evolution. For example, suppose we study the alliance relationships (the tie) that link nonprofit organizations (the nodes). Initially, it may be that none of the organizations have alliances with any other, defining a maximally disconnected network with as many components as nodes. Over time, alliances begin to develop and the number of components may reduce rapidly. Eventually, it is possible that all of the nonprofit organizations are connected in a single component in which every node can be reached from every other by at least one path (even if very long). Thus, by allowing the network to be disconnected, we can trace the evolution of connectivity within it. Thus, in this perspective, we do not ask "under what circumstances will networks emerge" (DTRA, 2006), as if they were groups. Rather, we ask how specific properties of the network, such as level of fragmentation or characteristic path length, change over time.

[3] Etic versus emic is a distinction made in cognitive anthropology between organizing the world using researcher-driven criteria (etic) and organizing things the way natives do (emic). The terms come from the linguistic distinction between phonetic (how things sound) and phonemic (how things mean).

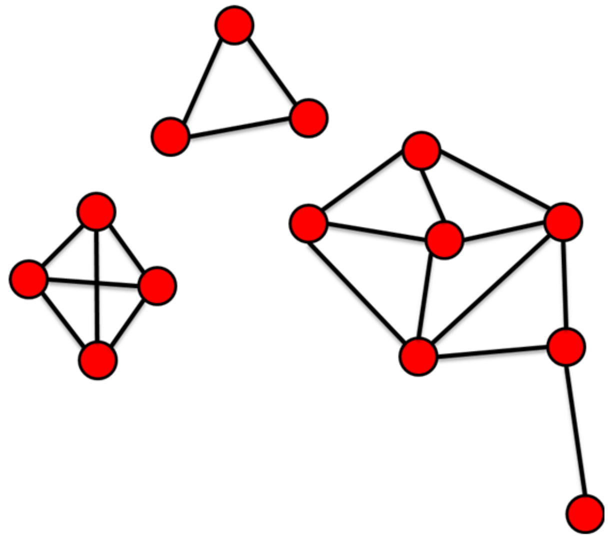


Figure 2. Network with three components

A closely related issue is what “counts” as a tie. A common beginner’s question is ‘which network questions should I ask in order to get at **the** network[5]’. Implicit in the question is the idea – labeled the *realist* position by Laumann et al., (1983) – that there is a “true” network of relationships out there and our job as researchers is to discover it. Given that assumption, it is reasonable to ask which social network questions have proven effective at eliciting this network. However, a more sophisticated view of social networks – labeled the *nominalist* position by Laumann et al., (1983) **--** holds that every network question (such as “who are you friends with?” “who do seek advice from?” “who do you share common board members with?” or “who do you trade with?”) generates its own network, and which to use is determined by the research question. Thus, a given research question may lead us to examine the advice and friendship ties within an organization, while another research question may lead us to examine ‘who likes whom’ ties. At the inter-organizational level we could study the alliance network linking firms, or the litigation network linking firms. No matter what kind of tie we are interested in, measuring that kind of tie among all pairs of nodes in the sample defines a network, and each network will have its own structure and its own implications for the nodes involved. For example, being an employee of an

[5] Social network data are typically collected from informants (interviews or questionnaires), observations, archival records (e-mail, membership in groups), or a combination of these methods. When using questionnaires, respondents are asked to identify the individuals with whom they have the relation of interest. See Brass and Halgin (2011) for a more indepth discussion.

organization central in a strategic alliance network might be and beneficial, while being an employee at an organization central in a lawsuit network might be painful and deleterious.

In practice, the kinds of ties that network theorists tend to focus on can be categorized into two basic types: relational states and relational events (see Table 1). States have continuity over time. This is not to say they are permanent but rather that they have an open-ended persistence. At the interpersonal level, examples of state-type ties include kinship ties (e.g., parent of), other role-based relations (e.g., friend of; boss of), cognitive/perceptual relations (e.g., recognizes; knows the skills of) and affective relations (e.g., likes; hates). State-type ties can be dimensionalized in terms of strength, intensity, and duration.

In contrast, an event-type tie has a discrete and transitory nature and can be counted over periods of time. Examples of event-type ties include email exchanges, phone conversations, and transactions such as sales or treaties signed. Cumulated over time, event-type ties can be dimensionalized in terms of frequency of occurrence (e.g., number of emails exchanged). It is these kinds of ties that researchers have in mind when they define networks as “recurring patterns of ties” (e.g., Dubini and Aldrich 1991; Ebers 1997; Jaffee, McEvily, Tortoriello 2005).

Both relational states and relational events can be seen as roads or pipes that enable (and constrain) some kind of flow between nodes.[6] Flows are what actually pass between nodes as they interact, such as ideas or goods. Hence two friends (state-type social relation) may talk (event-type interaction) and, in so doing, exchange some news (flow). As we discuss in the next section, one large swath of network theory is about how position in a backcloth network determines the timing or quantity of flows to the actor occupying that position.

[6] This is Atkin’s (1972) “backcloth/traffic” distinction.

Table 1: Types of Interpersonal Social Ties

Relational States				Relational Events
Social Relations		Mental Relations		Interactions
Kinship	Other Role	Affective	Cognitive	
e.g., Mother of, Sibling of	e.g., Friend of, Boss of, Student of, Competitor	e.g., Likes, Hates	e.g., Knows, knows about, sees as happy	e.g., Talked to, Advice to, Helped, Attacked

We might also note that, in empirical studies, researchers often make use of relational states and events that are not, properly speaking, social ties. For example, a frequent proxy for social ties is group co-membership, such as being on the same board of directors or belonging to the same social club. Similarly, co-participation in events, such as parties, is used as a proxy for unobserved social relationships. Other dyadic variables of this type include geographic proximity (Allen 1977) and similarity of traits such as behavior, beliefs and attitudes (McPherson and Smith-Lovin 1987; McPherson, Smith-Lovin and Cook 2001). From a theoretical point of view, co-memberships, co-participations, geographic proximities and trait similarities can all be seen either as dyadic factors contributing to the formation of ties (e.g., meeting the other members of your club), or as the visible outcomes of social ties (as when close friends join the same groups or spouses come to hold similar views).

While the majority of social network analysis has an interpersonal focus, we believe that a similar typology of ties can also be applied to collectives. While affective and mental relationships might not apply, the more general categories of states and events certainly do (see Table 2). For instance, organizations are connected to others through relational states such as formal alliances, partnerships, joint-ventures and others. These partnerships are often associated with interactions that facilitate resource flows between organizations (e.g., employee flows, trade, resource transactions). In addition, we believe that many of the same theoretical mechanisms that we discuss can also be applied to inter-organizational research.

Table 2: Types of Inter-organizational Ties

Relational States	Relational Events
Partnerships	**Interactions**
e.g., ally of, competitor of,	e.g., employee flows, trade volume, resource transactions, lawsuits

Characterizing Network Theory

Examining network analysis from a meta-theoretical point of view, we see two common features of network theory. First, the twin notions of structure and position play a fundamental role. For example, a well-known network theory is Burt's (1992) structural holes theory of social capital. The theory of structural holes is concerned with ego-networks – the cloud of nodes surrounding a given node, along with all the ties among them. Burt argues that if we compare nodes A and B in Figure 3, the shape of A's ego-network is likely to afford A more novel information than B's ego-network does for B, and as a result A may perform better in a given setting, such as an employee in a firm. Both have the same number of ties, and we can stipulate that their ties are of the same strength. But because B's contacts are connected with each other, the information B gets from, say, X may well be the same information B gets from Y. In contrast, A's ties connect to three different pools of information (represented by circles in Figure 4). Burt argues that, as a result, A is likely to receive more non-redundant information at any given time than B, which in turn can provide A with the capability of performing better or being perceived as the source of new ideas. Such arguments can also apply to networks connecting organizations (i.e., firms with alliance networks similar to node A likely have access to more diverse inputs than those like node B).

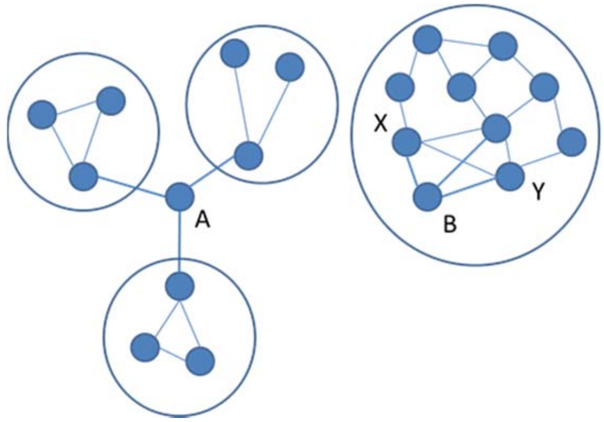
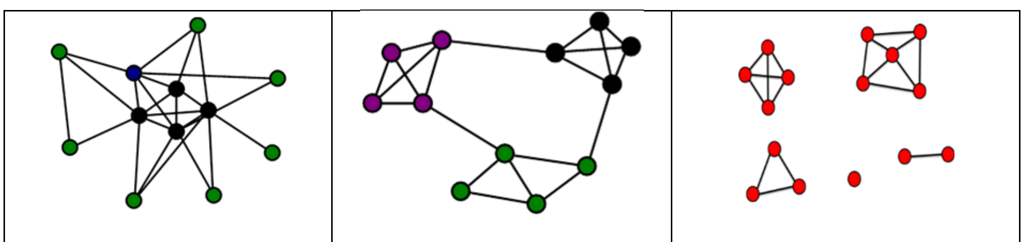


Figure 3. Structural Holes

It is the shape of the ego-network around the focal actor that confers advantages to the actor. Note that the theory ignores ego's own attributes (such as how creative they are) and also the attributes of ego's contacts (e.g., how smart they are, how gullible, how powerful) and only looks to see whether the alters are numerous and unconnected. This is not to say that ego and alter attributes are not important (they may well be much more important); it is just that the agenda of the theory – and the charter of network theory in general – is to explicate the connection between structure and outcome, and one aspect of this agenda is the study of the pure effects of structure. To be clear, the general agenda of examining the consequences of network structure includes the examination of how structure and attributes interact to yield outcomes.

Network structure is also key concept at a higher-level of analysis. Consider the three network configurations displayed in Figure 4. Network A, termed a core-periphery structure is characterized by a clear set of densely-connected core individuals and a set of less-connected peripheral individuals who are loosely connected to the core (Borgatti and Everett 1999). Network B is comprised of three clusters connected by bridging ties. Network C is disconnected and comprised of multiple components. These different structures will have very different implications for network members. Consider if these are communication ties among members of a work department. Whereas information can efficiently flow through network A, the lack of connectivity in Network C prevents the sharing of information throughout the network and might negatively influence the performance of a work department that requires collaboration. Members of network C might also experience a sense of conflict between connected clusters. This is not to say that a connected network structure is always better than others. For instance, a core-periphery structure (Network A) might stifle organizational change and signify a clear status hierarchy with a group of “insiders” and peripheral members. Similarly, there can also be benefits associated with less-connected structures. For instance, at the interpersonal level, the cluster model of Network B might encourage the development of creative and diverse ideas that can then be integrated by a department manager. Likewise, a disconnected network (network C) might be ideal for situations in which different groups are responsible for different types of work and there is no plan to integrate the production outputs. One can also imagine that if the networks consisted of interactions collected as part of a public health studying the spread of a disease, the implications of structure and position would be very different. In summary, we are simply pointing out that network structure has important consequences at both the individual and network level. Such effects also depend on the type of tie and the goals of the network.



Network A	Network B	Network C

Figure 4. Network Structure

Second, there is an implicit theory of the flow or distribution of information. In effect, many network studies rely on an underlying model of a social system as a network of paths which act as conduits for information to flow. We refer to this as the *flow* or *pipes* model. The abstract flow model carries with it some basic assumptions, such as the longer a path, the longer it takes something to traverse it. From this general model we can readily derive a number of theoretical propositions that form the core of many network theories. For instance, nodes that are far from all others will, on average, receive flows later than nodes that are more centrally positioned. Similarly, nodes that are embedded in locally dense parts of a network will often receive the same bits of flow from their various contacts, because the contacts are tied to each other as well. As discussed, nodes who are part of a connected network (e.g., Network A) are more likely to globally share flows than nodes who are part of a disconnected network (e.g., Network C). This is true for networks of individuals as well as networks of collectives.

Given that things flow through the network according to certain rules, there are some obvious outcomes that can be predicted as consequences of the network structure. For instance, at the node level, we may be interested in the expected time until (first) arrival of whatever is flowing through the network. Certain (central) nodes are positioned in such a way that, on average, they receive the flow sooner than other nodes. We may also be interested in how often or with what level of certainty a node receives a given bit of flow. At the network level, we might seek to understand fault lines and disconnects to orchestrate the formation of ties to improve the flow of information through a network. Or, we might identify which nodes if removed will maximally disrupt network flows (e.g., public health researchers can use this approach to stop the spread of a disease). What we do in network research is to relate features of the observed network to outcomes such as performance in an organizational setting and elaborate how a given network structure interacts with a given process (such as information flow) to generate outcomes for the nodes or the network as a whole. While the flow model is the most developed theoretical platform in network theory, it is not the only one, see Borgatti and Halgin (2011) for a discussion of other models.

The third thing to be noted about network theory is that the core concept of the field – the network – is not only a sociological construct, but also a mathematical object. As a result, it is sometimes possible to use the machinery of mathematics to generate new theory. For instance, Rapoport (1963) and others showed that transitivity tends to create highly clustered graphs that have many long paths or have disconnected components (similar to Network C in figure 4), which means that networks with high transitivity are slow or incomplete diffusers. More generally, the coincidence of sociological networks and mathematical networks makes it easy to generate formal theory that is expressed in mathematical form. This can be a blessing but also carries with it the danger that the non-mathematically inclined will not see it as theory at all, but rather as some form of statistics. A good example is the notion of betweenness centrality, which is defined by the formula shown in Equation 1. It has been shown (Borgatti 2005) that the betweenness formula gives the expected values of the number of times something reaches a node in a certain flow process (namely, one in which the things flow along shortest paths, and when there are multiple equally short paths they choose one of them with equal probability). Thus, what looks like methodology is in fact formal theory based on the flow model.

$$b_k = \sum_{i,j} \frac{g_{ikj}}{g_{ij}}$$

where b_k is the betweenness of node *k*, g_{ij} is the number of geodesic paths from *i* to *j*, and g_{ikj} is the number of geodesic paths from *i* to *j* that pass through *k*, *Equation 1*

Conclusion

Our principal goal in this article has been to dissect and characterize key concepts of network theory. In doing so, we have argued that much of network theory (and methodology) is based on the flow model, which is now well-elaborated and serves to unify large portions of network theory. While social network analysis has gained increased popularity we hope that our article highlights the long history of the field and clarifies key definitions.

We also hope that our article will aid efforts to improve international “networking behaviors” of the Jesuit community. Specifically, we believe that a reflection of the flow model of network theory can inform Society members’ understanding of both the challenges and possibilities of networking: Does the social fabric of the Jesuit community match the intended strategy going forward? What can be done to facilitate the creation and maintenance of a social structure that is fully aligned with goals of the community? Is the community effectively connecting with outside parties? When reflecting upon these questions we recommend that the community determine what types of relationships help support and spread the mission of the Society. For instance, one must recognize that information and resources that flow through formal reporting relationships and partnerships can differ from information that flows through trust ties or repeated social interactions. We must also consider the interpersonal networks within the order when thinking about how the community connects with the outside world. If a goal is to connect with other organizations, one must select the appropriate "representative brokers" (preferably individuals who are central within the community) to reach out to others.

We also encourage the community to consider a network mapping exercise. At the collective level one might investigate the ties that link provinces. For instance, one might use archival data to visualize aggregated partnerships among different Jesuit provinces (e.g., which provinces host visitors from others? Which provinces send members to the same conferences?). These ties likely serve as proxies for communication and information flows that connect the Society. Analyzing such data in network analysis programs such as UCINET (Borgatti, Everett & Freeman 2002) would reveal telling aspects of the Jesuit provincial network including the level of cohesion and centralization. If the network is connected (i.e., there are direct and indirect ties linking the provinces) and centralized (i.e., a core periphery structure) there is the potential for messages (including the common mission) to disseminate through the network. If the network is disjointed, one can imagine that the lack of social cohesion might result in multiple unique interpretations of the mission. Most importantly, these visualizations and descriptive statistics would reveal the current state of "networking behavior" in the community to better inform strategies aimed at aligning the social structure with future goals of the Society of Jesus.

We close by encouraging the reflection of various approaches to catalyzing tie formation in ways consistent with the mission of the network. There is no one proven solution, but if the mission is one of building solidarity and cohesion, one approach to fostering connections is through enhanced proximity. At the interpersonal level, offices can be relocated to encourage communication. At the organizational level, conferences and events such as this conference can be held to temporarily co-locate key members of disconnected (or network distant) organizations with the hopes that relational states and subsequent events will be formed. With conferences, one might also consider the interpersonal networks linking Jesuits when selecting attendees (these networks might include friendship, advice, trust, and others). Again, if individuals who are very peripheral within their local community attend a conference, the ensuing diffusion process might run into challenges. In the business world, managers can use incentives to promote desired network behaviors. Perhaps the Jesuit community can consider similar but culturally appropriate approaches. In summary, we hope that this paper and our upcoming conference will spark additional ideas helpful to the Society of Jesus.

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