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Part I

Introduction

1

Social Network Analysis: An Introduction

1.1 Introduction

While notions of social structure can be found in the writings of classical social theorists such as Auguste Comte, Emile Durkheim, Karl Marx, Herbert Spencer, and Max Weber, Georg Simmel is generally seen as the intellectual forbearer of social network analysis (SNA). Simmel ([1908] 1955, [1908] 1971) argued that to understand social behavior we must study patterns of interaction, and he offered penetrating insights into the nature of secret societies (1950b), the differing dynamics of dyads and triads (Simmel 1950a, c),[1] how increasing social complexity has led to concomitant rise in individualism ([1908] 1955), as well as others. While Simmel's theoretical contributions continue to influence the discipline today, SNA's early formal development can be traced to two major strands (Prell 2011; Scott 2000): the work of (1) social psychologists, such as Fritz Heider, Kurt Lewin, and Jacob Moreno (Heider 1977; Lewin 1951; Moreno 1953), who emphasized how organized patterns shape how we see and interpret the world; and (2) social anthropologists, such as Siegfried Nadel (1957) and Alfred Radcliffe-Brown (1940), who focused on the relationship between social patterns and social structure and who, in turn, influenced the research of social scientists such as Elton Mayo (1933, 1945; see also Roethlisberger and Dickson 1939), W. Lloyd Warner (Warner and Lunt 1941), John Barnes (1954), Elizabeth Bott (1957), and J. Clyde Mitchell (1969). These individuals did not create a distinct SNA paradigm, but their efforts laid the groundwork for its development at Harvard in the 1960s and 1970s, in an effort led by sociologist Harrison White and his students, including Ronald Breiger, Ivan Chase, Bonnie Erickson, Mark Granovetter, Michael Schwartz, and

[1] A dyad is a pair of actors with a tie between them. A triad is a set of three actors that may or may not have ties among them.

Barry Wellman (Freeman 2004; Prell 2011; Scott 2000). White, who also earned a Ph.D. in theoretical physics, emphasized the need for an empirically based social science that unapologetically focused on social phenomena. He argued that sociology, in spite of its claims to study social phenomena, was beholden to individualistic forms of analysis that drew conclusions based on the aggregated characteristics of individuals, often aided by statistical analysis of survey data. This, he believed, was a mistake. Thus, along with his students, he developed an approach that drew on case studies to focus on social relations and the patterns that emerge from them. The result is what we now know as social network analysis, and the discipline has blossomed ever since (Freeman 2004; Prell 2011). Social network analysts have created their own organization (International Network for Social Network Analysis), launched their own journals (*Connections*, *Social Networks*, and the *Journal of Social Structure*), gathered annually in either North America or Europe (Sunbelt meetings), and produced a number of monographs on SNA (de Nooy, Mrvar, and Batagelj 2005, 2011; Degenne and Forsé 1999; Knoke and Yang 2007; Scott 2000; Wasserman and Faust 1994).[2]

In recent years physicists and other scientists have entered the field, which has helped lead to an increased interest in SNA, attracting researchers from a wide array of disciplines and generating a number of highly creative studies (see, e.g., Barabási 2002; Barabási and Albert 1999; Buchanan 2001, 2002; Girvan and Newman 2002; Kleinberg 1999, 2000; Onnela et al. 2007; Watts 1999a, b, 2003). Unfortunately, many of these network scientists have been unaware of SNA's rich theoretical history (Scott 2011), which has led to a split in the field and the unnecessary replication of previous research:

> The physicists Barabási and Albert, for example, reported a "new" result having to do with the tendency of nodes in a network to display gross inequalities in the number of others to which they are linked. And they went on to develop a model designed to explain that tendency. But Paul Lazarsfeld had described the same tendency in 1938 (Moreno and Jennings 1938),

[2] The story, of course, is more complex than this brief account. For example, faculty and students at University of California, Irvine, made significant contributions (Freeman 2004:155–158). In fact, one faculty member, Linton Freeman, developed the first version of UCINET, probably the most widely used social network software in the world, and one of his students, Stephen Borgatti, along with Martin Everett, has since taken over its development. Other traditions that have informed SNA include graph theory (Harary 1953, 1969; Harary and Norman 1953; Lewis 2009), exchange theory (Cook and Whitmeyer 1992; Emerson 1972a, b, 1976), and research into the recruitment of individuals to religious and social movements (Gould 1991, 1993a; Lofland 1977; Lofland and Stark 1965; McAdam 1986, 1988b; Snow and Phillips 1980; Snow, Zurcher and Ekland-Olson 1980).

and Derek de Solla Price had developed essentially the same model as early as 1976. (Freeman 2004:166)

Nevertheless, there are signs that the two communities are bridging the gap. Duncan Watts, for example, took a position in the sociology department at Columbia University, and network scientists routinely attend the annual Sunbelt meetings (Freeman 2004). Thus, the long-term prospect for collaboration between the two groups looks promising, which will undoubtedly lead to further advances in the field.

What exactly is SNA? Briefly, it is a collection of theories and methods that assumes that the behavior of actors (whether individuals, groups, or organizations) is profoundly affected by their ties to others and the networks in which they are embedded. Rather than viewing individuals (and groups and organizations) as unaffected by those around them, SNA assumes that we are social beings whose interaction patterns affect what we do, say, and believe. Interaction patterns are anything but random, of course. Actors tend to interact with similar others, and repeated interaction can lead (among other things) to the emergence of social formation at the micro (e.g., individual), meso (e.g., group), and macro (e.g., institutions, nations) levels that can be the object of SNA in their own right. Intense social interaction can generate feelings of group solidarity, norms of behavior, symbols of group belonging (e.g., team mascots, gang colors, national flags, sacred religious symbols such as the Christian cross and the Jewish star, etc.), and a sense of identity (Collins 2004; White 1992, 2008). All of this is just a fancy way of saying that social networks not only enable and constrain behavior but that they are also chock-full of meaning (White 1992, 2008),[3] and as such help us make sense of our world, shape our preferences, and influence the choices we make (Passy 2003:23). Consequently, a primary goal of SNA has been to develop metrics that help analysts gain a better understanding of a particular network's structural features. And although organizational theorists tend to explore such questions with the goal of identifying factors that will help strengthen organizations, those who study dark networks are generally more interested in identifying those aspects that will undermine them.

The remainder of this chapter introduces the basic terms, concepts, and assumptions of SNA as well as considers certain issues germane to this approach. It begins with a discussion of common misconceptions of what SNA is and how it differs from other analytic approaches. It then briefly discusses SNA's basic terms and concepts before moving to an extended exploration of the assumptions that underlie it. The chapter's final section considers the roles that human agency and culture play within SNA.

[3] Technically, in White's view meaning comes from switching between networks (Steiny 2007).

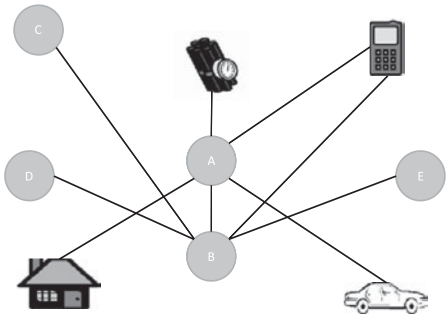

Figure 1.1. Illustrative Link Analysis Diagram

1.2 Misconceptions and Differences

SNA differs from other analytic methods and is often mistaken for other theoretical traditions. For example, the term *network* is used in different ways. Within some circles networks are seen as decentralized, informal, and/or organic types of organizations, and hierarchies are seen as centralized, formal, and/or bureaucratic types (Arquilla and Ronfeldt 2001; Burns and Stalker 1961; Podolny and Page 1998; Powell 1990; Powell and Smith-Doerr 1994; Ronfeldt and Arquilla 2001). This distinction is useful (and appropriate) in some theoretical contexts, but within the world of SNA all organizations are seen as networks. Some may be more hierarchical than others, but they are nevertheless networks (Nohria 1992). Indeed, algorithms have been developed that measure the degree to which a particular network is hierarchical (see, e.g., Davis 1979; de Nooy et al. 2005:205–212; Krackhardt 1994). This is not to say that there is a right or wrong way to use the term network. Rather, the term means different things in different contexts, and within SNA everything is considered a network.

SNA is also sometimes confused with link analysis, a related but distinct analytic approach that also examines the relational patterns of various objects. The basic difference between the two approaches is that although link analysis diagrams often include different types of objects (e.g., individuals, cars, cell phones) and the ties between them, social network diagrams only include ties between similar types of objects. Take, for example, a link analysis diagram where two individuals (A and B) each have links to five other objects, but the objects to which they have ties differ from one another (Figure 1.1). In this example, person A is linked to person B as well as a bomb, a cell phone, a house, and a car, whereas person B is linked to four individuals (A, C, D, and E) and a cell phone. Although both have five ties (which is the definition of *degree centrality* – see

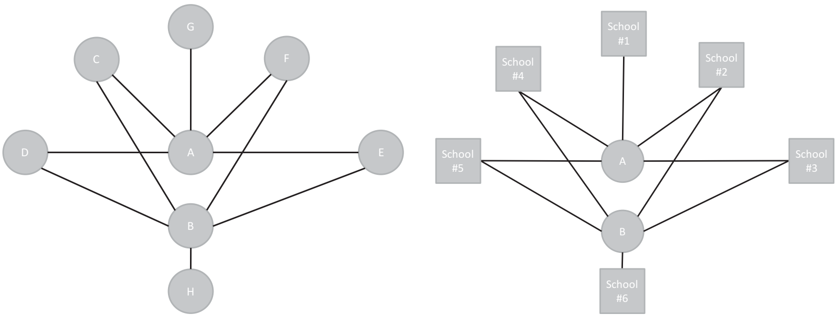

Figure 1.2. Illustrative SNA Diagrams

discussion in Section 7.1), we cannot meaningfully compare the number of ties of these two individuals because the ties are to different types of objects. It would be like comparing apples and oranges.

By contrast, in an SNA diagram actors have ties to similar objects, making direct comparison of numbers of ties meaningful. This is illustrated in Figure 1.2 where in the left panel individuals A and B each have five ties to five other individuals, and in the right panel they have five ties to five different schools. In both cases, A's ties are comparable to B's because they are to the same type of object. Of course, social network analysts are interested in more than the count of an actor's ties (although degree centrality is one of the oldest and most common metrics used by social network analysts), but other SNA algorithms generally assume that ties are between similar types of objects as well.

Finally, SNA differs from more traditional approaches (i.e., variable-based) in that although the latter focus on actors' attributes (e.g., gender, race, education) and ignore the broader social interaction patterns in which they are embedded (e.g., at home, work, and place of worship), SNA focuses on how these interaction patterns affect behavior, noting that although many attributes remain the same across social contexts, most interaction patterns do not, suggesting that interaction patterns are just as (or perhaps more) important for predicting and understanding behavior than are attributes:

> A woman who holds a menial job requiring little initiative in an office may be a dynamic leader of a neighborhood association and an assertive PTA participant. Such behavioral differences are difficult to reconcile with unchanging gender, age, and status attributes, but comprehensible on recognizing that people's structural relations can vary markedly across social contexts. (Knoke and Yang 2007:5)

SNA, then, is a collection of theories and techniques that provide empirical content to social context. It has been used successfully to explain varieties of behavior because it forces researchers "to think in terms of constraints and options that are inherent in the way social relations are organized" (Raab and Milward 2003). For example, Padgett and Ansell (1993) found that whether or not certain elite families in fifteenth-century Florence supported the Medicis or one of their rival political factions depended more on the pattern of economic, patronage, and marital ties than on the various families' class and status attributes (Knoke and Yang 2007:5).

1.3 Basic Terms and Concepts

Actor

In SNA the term *actor* refers to discrete individuals, subgroups, organizations, collectivities, communities, nation-states, and so on that are involved in social relations. In other words, SNA does not always focus on individuals, a fact that is often ignored by analysts using SNA in their attempts to disrupt dark networks. Within SNA, actors are sometimes referred to as *nodes* and *vertices*.

Tie

Actors are linked together by *ties*. Ties can vary in terms of type, strength, and direction. Examples of types of ties include (adapted from Wasserman and Faust 1994:18):

- Ties of sentiment (friendship, liking, respect)
- Resource ties (business transactions, financial flows)
- Ties of association or affiliation (members of the same church, club, etc.)
- Behavioral ties (communication ties)
- Ties based on geographic movement (migration, physical mobility)
- Ties based on status movement (social mobility)
- Ties based on physical connection (road, river, or bridge connecting two points)
- Formal ties (organizational hierarchy)
- Biological ties (kinship)

Ties can be said to vary on a continuum from strong to weak (Granovetter 1973, 1974). At the individual level, we can think of strong ties as those where actors have repeated and relatively intense interactions with one another, whereas we can think of weak ties as those where actors see one another occasionally or rarely. Nevertheless, it is not always self-evident where the cutoff between a strong and weak tie exists (Krackhardt

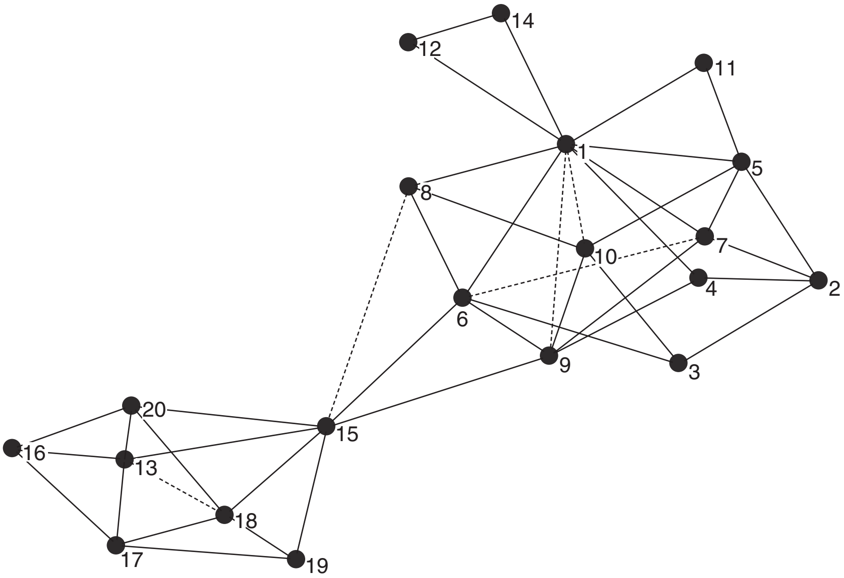

Figure 1.3. Hypothetical Social Network

1992). Moreover, what distinguishes a weak tie from the numerous, random, and usually unrepeated encounters actors experience daily is not always clear (Azarian 2005:37). Determining a threshold or cutoff value for identifying what constitutes a tie is (or at least should be) a difficult task. It is helpful to think of a social tie as "a theoretical construction, abstracted by the analyst from the bulk of largely erratic streams of affections, encounters, and interactions between a pair of actors, be they human beings, informal groups, formal organizations, or others" (Azarian 2005:37). A tie that has directionality (e.g., the flow of resources from one actor to another, where one actor communicates with another actor) is sometimes referred to as an arc. A tie that does not have directionality (e.g., spouse, kin) is sometimes referred to as an edge.

Social Network (and Social Network Analysis)

A social network is "a finite set or sets of actors" that share ties with one another (Wasserman and Faust 1994:20), and social network analysis involves "detecting and interpretating patterns of social ties among actors" (de Nooy et al. 2005:5). Figure 1.3 depicts a hypothetical social network where the circles represent actors and the lines (solid and broken) represent ties or relations. As this network illustrates, seldom are actors located randomly in networks; instead, they typically cluster within relatively distinct subgroups. Moreover, some actors are embedded deeply within a subgroup, while others sit more on the periphery, sometimes serving as bridges between subgroups.

Path (and Path Distance)

Notions of *path* and *path distance* are probably easier to illustrate than define, so here we do both. A *path* is defined as a *walk* (i.e., a sequence of actors and ties) in which no actor between the first and last actor of the walk occurs more than once, whereas the *path distance* between two actors is the number of steps between the two actors (Wasserman and Faust 1994:107).[4] Looking at Figure 1.3 you can trace a path from actor 9 to actor 19 through actor 15, and a path from actor 6 to actor 11 through actor 1. In both cases the distance between the actors is two (i.e., two steps). It is quite common for there to be numerous paths between actors, with some paths longer and shorter than others. The shortest path between two actors is known as a *geodesic*.

Topography

Networks differ from one another in terms of their overall structure or *topography*, and evidence suggests that a network's topography has a strong impact on the behavior of its members and is related to its performance and/or efficiency. For example, researchers have found that network density is positively related to the likelihood that actors within the network will follow accepted norms and behavior, which is why a primary basis for moral order is highly connected social networks. Why? One reason is that in dense networks it is easier for people to monitor the behavior of others and prevent them from engaging in deviant behavior (Granovetter 1992, 2005). Another is that most people are more likely to conform to social norms when they run the risk of losing their relationships to others if they do not (Finke and Stark 2005), and in dense networks we are more likely to have ties (relationships) that we are unwilling to lose, whereas in sparse networks we often lack the social ties that would otherwise prevent us from misbehaving. Take frontier areas like the Wild West, for instance. People are constantly passing through, which makes it hard for social ties to form, so social networks tend to be sparse. Sparse networks also make it difficult for institutions

[4] When discussing traveling from one actor to another, social network analysts distinguish between three types of connections: walks, trails, and paths. A *walk* is a sequence of actors and ties that begins and ends with actors and can involve the same actor more than once. A *trail* is also a walk but a particular tie can only be traversed (i.e., used) once. Thus, while all trails are walks, not all walks are trails. Finally, a *path* is a walk where, with one exception, each actor and each tie can only be used once. The exception is that the beginning and ending actor can be the same. See Wasserman and Faust 1994:105–108.