ONE

INTRODUCTION TO SOCIAL NETWORK ANALYSIS

1.1 INTRODUCTION

The study of social networks is a new but quickly widening multidisciplinary area involving social, mathematical, statistical, and computer sciences (see Burt, Minor, & Associates, 1983, for application in diverse social environments; in the latter sciences, see Wassermann & Faust, 1994, and especially for the field of economics, see Dutta & Jackson, 2003). It has its own parameters and methodological tools. In this book, we intend to show how graph-theoretic and statistical techniques can be used to study some important parameters of global social networks and illustrate their use in social science studies with some examples of real-life survey data. We hope our illustrations will provide ideas to researchers in various other fields as well.

1.2 CONCEPT OF A SOCIAL NETWORK

The term *social network* refers to the articulation of a social relationship, ascribed or achieved, among individuals, families, households, villages, communities, regions, and so on. Each of them can play dual roles, acting both as a unit or node of a social network as well as a social actor (cf. Laumann

& Pappi, 1976). Kinship is a very common example of an ascribed relationship, while some common examples of an achieved relationship are those that are established in the course of regular interaction in the processes of daily life and living, cultural activities, and so on, such as one household requesting help, support, or advice from another; ties of friendship or choice of individuals to spend leisure time together; and preferences in marriage. Incidentally, a relationship can also be *negative*—for instance, hostility or conflict as opposed to friendship or alliance and alienation versus mutuality or integration. In this book, we will focus on *positive relationships*. Again, much of what we will discuss is based on sociological data, but it can also be used to study demographic and economic processes such as migration from one region to another, value of any type of economic (e.g., postal money order or trade) exchange between regions, volume of flow of goods between countries, flow of traffic between different places, and so on.

Thus, the units of a "social network" can be different, no doubt, such as individuals, families, households, and rural or urban areas, according to the relationship under consideration. But there is a common feature—namely, whatever the type of units we study, a specific dyadic relationship exists or does not exist between the members of any pair of them.

Furthermore, if the relationship exists between a pair of units, it is also quite pertinent to ask whether it flows in both directions or only in one direction and, in the latter case, from which direction to the other, because a social relationship is not necessarily symmetric. Asymmetric relations, such as the following examples, are as common as symmetric ones. For instance, A prefers B, A invites B to a household festival, or A goes to B for help or advice. But B may or may not prefer, invite, or approach A.

We should mention, however, that only because of the presence of such pairwise ties, a *social network* should not be equated with *social group*. There are two concepts of a social group: realist and nominalist. The realist concept is most commonly used in sociological parlance. According to this concept, it is an entity consisting of social actors such as individuals, families, and so on and is set apart from the rest. A social group retains a multidimensional system of somewhat durable contacts or interactions within the group: psychic, emotional, verbal, and behavioral. Thus, there is an element of a feeling of awareness or consciousness shared by its members. Besides, a social group generates its own boundary within which its members obey certain rules, norms, and functional roles toward each other as well as toward its common

goal. (For a detailed discussion of different characteristics of social groups, see Homans et al., 1968.) However, moving outside the realist concept of social group, a researcher also enjoys the option to impose his or her own definition of the boundary of group membership to identify a group for a study. This is the nominalist concept of a social group. For example, compare the Marxian concept of class as a "class for itself," a realist concept, and a class as "class in itself," the nominalist view (Laumann, Marsden, & Prensky, 1983). Wasserman and Faust (1994) have followed the nominalist concept of a social group for an illustration of methods. Thus, while a social group can be both realist and nominalist, a social network cannot be a realist one. A social network is a category of actors bound by a process of interaction among themselves. It is thus a nominalist category. However, a social network or its parts are endowed with the potential of being transformed into a social group in a realist sense provided that there is enough interaction.

For analytical purposes, a social network is conceptualized as a *digraph* (or a *graph* if the relationship has no direction). Digraph diagrams may be drawn to instantly provide direct mapping of ties showing their clustering as well as scatteredness. In a digraph, we call a unit—whether an individual, a family, a household, or a village—a *vertex* or *node*. A tie between two nodes indicates the presence of the relationship connecting them. Absence of a tie indicates absence of the relationship. A tie with a direction is called an *arc*, and a tie without direction is called an *edge*. One could also note the value or volume of flow as the weight of a tie and thus obtain a network that would then be a *weighted digraph*. More precise definitions of the graph-theoretic terms will be given in Chapter 2. Since the structure of the same network can be visually perceived differently depending on the manner in which a diagram is drawn, it is necessary to eliminate the bias in visual perception in order to draw an inference about the structure of a network from a digraph diagram (McGrath, Blythe, & Krackhardt, 1997). This visual bias is eliminated if we take recourse to numerically measure some of the selected important characteristics of a network and draw inference from there (see Chapter 6 for illustration).

For the sake of simplicity, we will concentrate on social networks showing only the presence (1) *or absence* (0) *of the relationship*. We also assume that ties have directions. Later, in Chapter 6, we will indicate, citing reciprocity as an illustration, how social network analysis can be extended to the case when the 0–1 restriction is dropped and there are nonnegative weights associated with the ties.

Networks are usually represented by diagrams where the vertices are represented by points, arcs by lines with arrowheads, and edges by lines without arrowheads. When two nodes are connected by ties in both directions, we often represent the two ties together by an edge, omitting the arrowheads.

1.3 SOCIAL NETWORK ANALYSIS

Search for a Theoretical Base in Sociological Theories of Generalized Social Exchange Behavior—A Brief Interlude Social network analysis (SNA) means analyzing various characteristics of the pattern of distribution of relational ties as mentioned above and drawing inferences about the network as a whole or about those belonging to it considered individually or in groups.

Beginning its journey as a descriptive metaphor, social network, in the course of the past few decades, has, as a parallel to the theories of market exchange, carved out a position for itself in the realm of theories and methodology for the study of society (Collins, 1988). Although its theoretical premise seems to be very close to market theories, it does not consist of looking for a best bargain in the case of an utilitarian exchange of goods and services. Rather, as a matter of generalized social exchange, it conceptualizes exchange not only in terms of economic interest but also of reciprocal role expectations as well as value orientations, social norms, and obligations. (See Homans, 1961, and Blau, 1964, for explication of the basic ideas relevant to understanding the rationale of the workings of social network, and see Turner, 1987, for a comprehensive discussion of social exchange and exchange network theories.) These attributes have made network theory more comprehensive and flexible enough to accommodate both asymmetric and symmetric relations as its natural elements. Hence, while social network theory does not deny the role of traditionally used a priori structural-functional concepts and categories in social research such as family, kinship, caste and ethnic groups, status groups, class, strata, and organization, it sees the actors and their roles and positions in a real-life situation rather in the light of the crystallization of patterns of interactions among individuals (Laumann, 1966; Wellman, 1988). This has also been discussed in detail in the context of Indian society (Srinivas & Beteille, 1964).

Social network theories do not consider individuals as forming a mechanical aggregate but as an organic whole where the constituent elements are connected among themselves as well as with the others through a mosaic of

ties based on interactions, directly or indirectly, at various domains such as social, economic, political, and the like. This enables a social network to be quite flexible to include the ties of the relationship of a social actor, which exist in ground reality even if those fall outside the boundaries of traditional social categories and derive appropriate ways to incorporate them in theoretical and methodological structure befitting the dynamics in social reality. Thus, SNA, unlike conventional social science methodologies, is rooted in the fact that the social universe does not consist of an aggregate of mutually independent social actors. On the contrary, they exist in a system of interlinkages and interdependence, creating and structuring ties among themselves. (Incidentally, Berkowitz, 1982, has encapsulated the concept of SNA in the wider perspective of structural analysis.)

The methodology of SNA has also contributed to the formulation of precise quantitative measures of many qualitative concepts that have long been in use in the study of society but have remained vague often due to the degree of separation between the concept and the measure (Adhikari, 1960). Power, cohesion, fragmentation, reciprocity, hierarchy, cliques, and alliances are some examples. Dissatisfaction with prevalent macro theories of society, such as those of structural functionalism, therefore has led to an alternative in social network theories, particularly with respect to studying the lack of social cohesion and conflicting situations, steep asymmetry, and fragmentation in society.

Furthermore, SNA also serves as a powerful tool for the identification of changes in a pattern of group structure, whether it is the case of data obtained on participation in a small group; survey research with large communities such as villages, towns, and so on; or flows of population, trade, traffic, and so on among different regions.

The mainstream of social network studies in the past has been the study of personal networks, even though the central thrust is oriented toward "looking for community," "to discover it," in various areas of life and living of individuals (Wellman, 1997). The aim of this book is to supplement this by showing how one may obtain the social network of a community by undertaking a survey, how one may derive measures of various sociological parameters from SNA, and how combined with contextual data it can provide deep insight into the changing pattern of a society, its dynamicity. We will illustrate these at the end of this chapter with a quick comparison of the social networks of a large village community before and after various official measures aimed at

rural progress have been implemented during the past two decades, although a detailed analysis of the measures and comparison of various parameters is deferred until Chapter 6.

In this chapter, we also state the preliminaries of SNA along with its general features and some specificities, including different types of measures derived from it. In the following chapters, we discuss different mathematical and statistical models leading to the derivation of various measures and inference about them. With the help of analysis of live data derived from some cross-sectional and longitudinal case studies, we then illustrate in Chapter 6 (the chapter on case studies) the use of the techniques developed.

1.4 PRELIMINARIES

At the outset, we should point out that, as yet, there does not exist any set of standard methods of data analysis and inference for SNA as it exists in the case of commonly used economic or demographic variables in social science research. Methods of SNA, in fact, have evolved in an ad hoc manner according to the needs of the topic (Mitchell, 1969). Even then, the methodology of SNA shows a pattern on the whole. It is largely bifocal in the sense that we can broadly classify the methods as leading to *local measures*, which analyze the network attributes with respect to individual units or dyads, and the *global measures*, which study the characteristics of the network considered as a whole. The two types of measures are not unrelated. Rather, the latter can be obtained from the former in a few instances by some sort of aggregation, as in the case of density or reciprocity. It may also be noted that the usual statistical methods of data analysis and inference, such as measures of central tendency and dispersion, are applicable mainly in case of the former derived from personal attributes. In contrast, analysis of the global measures generally remains problematic as we will see later in the case of fragmentation, level of hierarchy, reachability, and so on. By their very nature, for such characteristics of a network, either there is no local measure or the global measure cannot be obtained by aggregation of the local measures.

Vertices and arcs and their counts are the basic data used for analysis of a social network. These are used to obtain the values of various parameters of the network. We now give a few such parameters of a social network, discuss their social meaning and significance, and show how one can apply them in not only

describing a social situation but also studying its dynamicity. Last, we conclude by describing, with the help of digraphs, how SNA, applied to actual data on a village community at two points of time, provides insight into its structural dynamicity. In fact, the findings from this study (especially the changes in the parameters over time) have emboldened us to ponder over questions such as the following: Is what we observe to be happening in the village community today a matter of random drift, or does it indicate that it is standing on the threshold of a social transformation in the society?

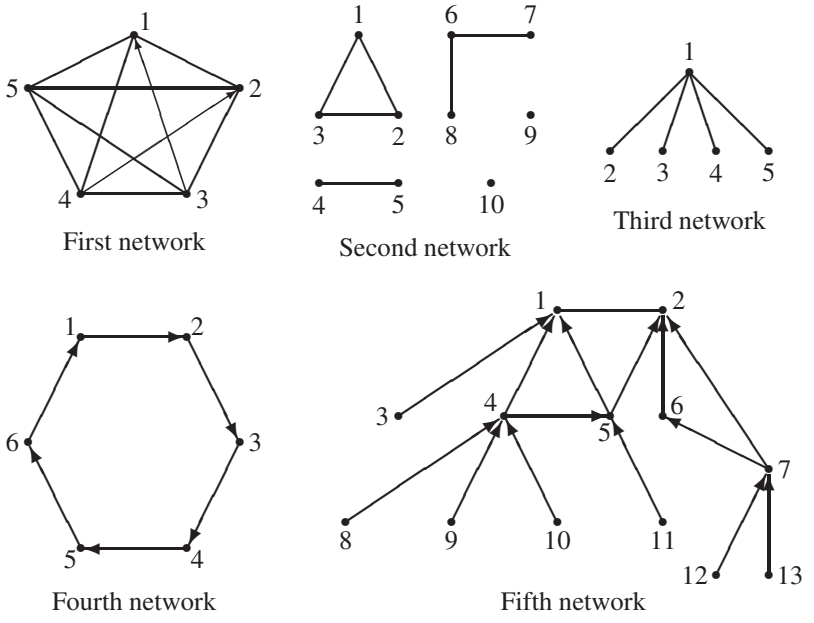
Before we proceed to the study of specific characteristics of a social network, we make a few general observations.

We emphasize that in social network analysis, we study *dyadic relation* (which involves a pair of nodes), whereas in the usual statistical or socio-economic surveys, one studies one or more attributes of a *single* node such as income, educational status, age, family size, and so on, which are assumed to be statistically independent. But the data of social network blatantly violate this assumption. For this reason, the usual statistical techniques may not always be applicable to SNA. Moreover, whereas the analytical forms of the first few theoretical moments give a reasonably good picture of a statistical distribution, there seems to be a large number of features of a social network, each of which can vary independently of the others and may not be amenable to statistical study only through their moments. Even if the measures are amenable to statistical analysis, it requires an extremely complex exercise to derive exact statistical formulae for estimation of these measures, especially when one is considering global measures. Besides, a whole social network is a unique case and, as such, has not been drawn at random from a pool of social networks. Hence, the usual mode of drawing statistical inference is also not valid. Again, global characteristics of a social network, even its out-degree and in-degree sequences, cannot be assumed to be necessarily normally distributed; they follow exponential or power law, mostly in a finite range. Hence, it requires selection of appropriate nonparametric statistical tools for SNA data.

In Figure 1.1, we give five hypothetical social networks involving a small number of nodes to illustrate some of the wide variety of networks possible.

For example, the first network involving 5 nodes in Figure 1.1 is close to the situation where everybody goes to everybody else. In the second network involving 10 nodes, the ties are all reciprocated, but the network is highly fragmented. The third network, comprising 5 nodes, is connected but shows

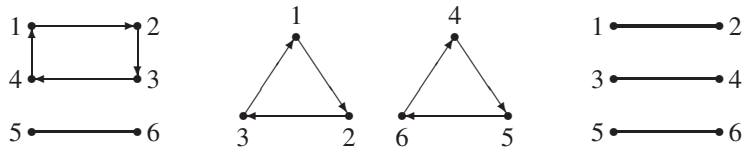
Figure 1.1



concentration of power. It is held together by a single node (number 1) whose disappearance will cause the disintegration of the network. The fourth network involving six nodes is also connected in the sense that everybody can go to everybody else but through a large number of intermediaries. The fifth, involving 13 nodes, displays a strong hierarchy, and although it is connected, the ties flow only in one direction.

Vertices and arcs provide the primary constituent data set in a network. Even if these are fixed, the distribution of the ties among the vertices and the structure of the network can vary significantly. We illustrate this with the hypothetical example of six households in a neighborhood connected as in the fourth network in Figure 1.1 through six ties. Note that in this network, each of the households goes to exactly one among the remaining five, and only one of the remaining five comes to each household. Even if we impose this further condition, there are three other patterns possible besides those shown in Figure 1.1, which are presented in Figure 1.2.

Figure 1.2



Need for Standardization

For the purpose of comparing different social networks, one has to carefully standardize the parameter in question to get a measure. To illustrate this, consider two social networks N_1 and N_2. Suppose the vertices represent persons, and a tie from u to v indicates that u goes to v to spend (some of) his or her leisure time. How do we find the answer to the following question: Which of the networks is more cohesive? By cohesion, we mean that the actors in a network are bound closely by ties of interaction. For example, suppose N_1 is a network with 10 vertices and 20 ties, and N_2 is a network with 100 vertices and 200 ties. Which network is more cohesive, or are they equally cohesive? Even though the second network has a larger number of ties, we cannot conclude that it is more closely tied up. Let us look at another network to illustrate this better. Suppose N_3 that has 5 vertices and 20 ties. Clearly, N_3 is more cohesive than N_1 since everybody goes to everybody else in N_3, whereas in N_1, on average, a person goes to only 2 out of the other 9. Thus, one has to standardize the number of ties in terms of the number of vertices properly before using it to compare two networks. How do we do this? The *density* of the network, defined as $m/n(n-1)$, provides a natural measure (Berkowitz, 1982, pp. 45–46). Here, and in what follows, n and m denote, respectively, the number of vertices and the number of ties in the network. Note that $n(n-1)$ is the maximum possible number of ties given that n is the number of vertices. Hence, the measure is $m/n(n-1)$. Density lies in the range of 0 to 1, irrespective of the number of vertices, and can be used to compare two networks. Clearly, the density is $20/90 = 22.2\%$, $200/9{,}900 = 2.02\%$, and $20/20 = 100\%$ in N_1, N_2, and N_3, respectively.

Although density as defined above is a good measure of cohesion (i.e., how closely the vertices are tied up in the network), what about its validity when n is large as in the network N_2? The implicit assumption in the

above-mentioned standardization is that every vertex *can* interact with all the others. Is it realistic in a real-life situation to hold that, in order to spend leisure time, each person potentially visits 99 others as a matter of regular practice? Perhaps one has to think of a *potential set* for each vertex u from which u makes its *actual* choices or one has to at least assume something about the size of this potential set. For example, if we assume that nobody can go to more than 10 others to spend leisure time, then the maximum possible number of ties in the network with 100 persons would be 1,000, and the density in N_2 would be revised to $200/1{,}000 = 20\%$, which perhaps gives a more realistic picture.

The main difficulty with the approach using potential sets is in determining them or their sizes because there is no unique way to decide what would be the potential set of a vertex. One researcher might decide in favor of asking the respondent directly to find out who belongs to his or her potential set, while another might hesitate since there would be no way to check data reliability. One might opt for a structural approach such as considering those who belong to the same ethnic category (e.g., caste, community, or locality) as constituting the potential set. However, that approach could make a potential set too large to be realistic. Again, one could come up with a solution such as the following example: The potential set for a vertex consists of those vertices that are reachable from the former, if needed, in a few, say two or three, steps (in forward or backward direction) in the network. However, one needs to verify whether the assumption that ties can easily be used in the reverse direction hold. Moreover, when the approach of potential sets is used, perhaps one should report the potential sets used along with the value of the measure. In view of these problems, one usually falls back on the density as defined earlier. However, But one needs to be cautious about the way data are standardized and in interpreting the values of the measures in general.

1.5 A FEW BASIC PARAMETERS

The two most basic parameters of a social network are the *number of vertices* n and the *number of arcs* m. We have already discussed how m can be standardized to get the *density* $m/n(n-1)$, a global measure of cohesion.

Since the arcs in the network may not be distributed uniformly over the vertices, one may be interested in the corresponding local measure that we call the *local density*. What is the counterpart of m for the ith vertex? It is

the number of ties d_i going out from it and is called the *out-degree* of the ith vertex. How do we standardize d_i? Since the minimum and maximum values d_i can take are 0 and $n-1$, we take $d_i/(n-1)$ to be the local density of the ith vertex.

There is another possible counterpart of m for the ith vertex: the number of ties e_i coming to it, known as the *in-degree* of the ith vertex. The corresponding local measure of density is $e_i/(n-1)$. We show that d_i and e_i signify entirely different things. However, it is easy to see that the sum of the d_is, as well as the sum of the e_is, is m. Hence, the global density is the average of the local densities of the vertices, whether they are based on the out-degrees or in-degrees. However, one traditionally takes $d_i/(n-1)$, rather than $e_i/(n-1)$, as the local measure, particularly when the network represents a sociological choice relation.

What is the sociological significance of the out-degree and the in-degree of a vertex? If it is a network of individual choice or preference (i.e., if a tie uv means that u chooses or prefers v), then the in-degrees of the vertices in the network indicate respective status by popularity, potential for influence or leadership, and so on. Out-degree of a vertex will then indicate its capacity for sociability.

On the other hand, suppose it is a matter of giving assistance or help and support, whether financial, material, or physical, or by counseling and providing advice at critical times when it is urgently requested (i.e., a tie uv means that u takes help from v). Then the in-degree of a vertex suggests its status in the network in terms of resource potential or the potential to lead someone to another who is resourceful. In-degree thus becomes a measure of potential power or influence as well. Out-degree, on the other hand, can be an indicator of buffer against vulnerability of the resource poor in the community. It can also bring out the extent of dependency. From the assessment of the ground situation based on available contextual data, appropriate interpretation of the finding (i.e., whether it is a matter of dependency or buffer against vulnerabilities) can be ascertained. In a general sense, out-degree denotes expansiveness.

Last, if both in-degree and out-degree of a vertex are zero, it is an isolate without any interaction with others in the social network being studied. Its interpretation again depends on contextual data. It may indicate a situation of self-contained self-sufficiency arising out of resourcefulness or, on the contrary, a state of atomization by fragmentedness where one does not care

for the other as if in a state of anomie or alienation from the others in the society (see Simmel translated and edited by Wolff, 1964).

The third basic parameter of a social network is the *number of reciprocal* (also called *symmetric* or *mutual*) *pairs* in it. This is the number s of unordered pairs of vertices $\{u, v\}$ such that both uv and vu are ties in the network. As a matter of sociological concept, reciprocity is not defined as an instantaneous phenomenon. It "does not mean equivalence of return on every occasion; equivalence is usually achieved over a long period of time" (Srinivas, 1952). As an illustration, we quote Mayer's (1975) idea of "balanced reciprocity," which we believe adds another dimension to broaden the meaning of the concept: "I had come to study and write a book; they had helped me to gather the material to do so; and I had returned with the book which was the result of our joint efforts . . . a reciprocally balanced relation between myself and Ram Kheri over the years."

How do we standardize s to get a measure of reciprocity so that it can be used to compare different networks? It is not difficult to see that in a network with n vertices, s can take all integer values from 0 to $n(n-1)/2$, so we may take $2s/n(n-1)$ as a standardized *measure of reciprocity*. However, this measure again implicitly assumes that everybody can interact and reciprocate with everybody else in the network. Thus, in a sense, it is a combined measure of reciprocity and cohesion. One may rather want a measure of the extent to which the arcs present in the network (whether they are small or large in number) are reciprocated. Then one fixes both the number of vertices n and the number of arcs m and standardizes s. It can be shown that the corresponding standardized measure of reciprocity is $2s/m$ provided $m \leq n(n-1)/2$. (Actually, the denominator in the measure should be reduced by 1 in case it is odd.) Following Rao and Bandyopadhyay (1987), the derivation of this and other measures of reciprocity is discussed in detail in Chapter 5. We have refrained ourselves from further studies of reciprocity using boundary specifications such as class, caste, kinship, and so on. The interested reader is referred to the work by Chatterjee, Bandyopadhyay, and Rao (1993).

Just as in the case of density, there may be wide variation in the degree of reciprocity displayed by different vertices in the network. Thus, one would like to have a measure of *local reciprocity* for a vertex. The counterpart of s for the ith vertex is the number s_i of other vertices with which it is tied up reciprocally. By dividing s_i by $n-1$, we get the standardized measure of local reciprocity of the ith vertex to be $s_i/(n-1)$. Since the sum of all s_is equals

$2s$ (recall that the definition of s involves unordered pairs), the global measure $2s/n(n-1)$ is the average of the local measures of all the vertices.

What is the local measure of reciprocity of the ith vertex corresponding to the global measure $2s/m$? We may take it to be s_i/d_i, where d_i is the out-degree of the ith vertex. Notice that now the global measure is a weighted average of the local measures, the weight of s_i/d_i is d_i. One may again wonder why not use the in-degree e_i instead of the out-degree d_i. The reason is that, usually, the out-degree is what is in the control of the ith vertex. Sometimes, instead of asking an open question, the out-degrees are determined by the investigator such as when he or she asks following the "fixed-choice" technique of the name generator, "Who are your three best friends?"

Reciprocity in a social network indicates some sort of balance or harmony, which can nullify the negative effects of social stratification. Local reciprocity of a vertex in the network of a social choice relation is an indicator of its social congeniality or level of being integrated with others in the network. Global reciprocity, on the other hand, is a measure of integration of its vertices among themselves. Hence, it becomes a measure of social solidarity of a group or community. In fact, global reciprocity was pointed out to be a distinctive characteristic of a community in the past. (See, for example, the writings of classical sociologists such as Durkheim or Tonnies.) The roots of theoretical properties of reciprocity have been researched in the sociological literature from various theoretical positions as a matter of a cultural norm of the society as well as functional explanation of its persistence (Gouldner, 1960), on one hand, and as a model of social exchange of resources, services, products, knowledge, and expertise, on the other hand (Collins, 1988).

We now give the values of the above measures for the networks in Figures 1.1 and 1.2. We start with the fifth network in Figure 1.1. It has 13 vertices and 16 arcs. Hence, its density is 0.103. It can be checked that the out-degrees and the in-degrees of the vertices are 1, 1, 1, 2, 2, 1, 2, 1, 1, 1, 1, 1, 1 and 4, 4, 0, 3, 2, 1, 2, 0, 0, 0, 0, 0, 0. Thus, the local density based on out-degree is 0.167 for the fourth, fifth, and seventh vertices and 0.0833 for the others. The local density based on in-degree is 0.333 for the first and second vertices, 0.25 for the fourth, 0.167 for the fifth and seventh, 0.0833 for the sixth, and 0 for the remaining vertices. It can be checked that the densities of the first four networks in Figure 1.1 are 0.90, 0.121, 0.40, and 0.20, respectively. For each of the networks in Figure 1.2, the density as well as the local density of each vertex is 0.20.

The last network in Figure 1.1 has only one reciprocal pair, so its measure of reciprocity, $2s/n(n-1)$, is 0.013. It can be checked that the measure is 0.80 for the first network, 1.00 for the second and third networks, and 0 for the fourth. It is 0.067, 0, and 1.00 for the three networks in Figure 1.2. The measure $2s/m$ is not applicable to the first network in Figure 1.1 since m is too close to $n(n-1)$. It is 1.00 for the second and third networks, 0 for the fourth, and 0.125 for the last. It is 0.333, 0, and 1.00 for the three networks in Figure 1.2.

We have indicated here only some of the important commonly used basic parameters of a social network. More detailed discussion—both graph theoretic and statistical—of these and some other complex parameters that can be used to study various aspects of a social network such as fragmentation, reachability, centrality, cliques, hierarchy, and structural equivalence will be given in Chapter 5.

As already stated, since theoretical probability distributions of the measures of global parameters as described above, as well as their estimation by drawing a sample of nodes, remain problematic, statistical tests for differences between networks with respect to them could not be performed unless one invoked a superpopulation setup or used computer simulation to estimate the distributions.

1.6 A COMPARATIVE STUDY OF THE SOCIAL NETWORKS OF A VILLAGE AT TWO TIME PERIODS

Objectives of the Study

Our illustration of social network analysis came out of a study undertaken first during 1971–1972 and later in 1997–1998. The fact that the economic structure of rural society in West Bengal is not egalitarian but stratified by sharp inequality in income distribution was argued a long time ago, supported by an extensive sample survey of households in a large number of villages (Mukherjee, 1957). The subject matter of our study is, rather, to explore the structural pattern of social relations in rural areas. Our concern was with how the "community" could survive in villages despite steep economic stratification.

For this purpose, we decided to scan the empirically derived structure that arises out of the pattern of interactions in rural society, especially in the course of the processes of help and support that people provide to one another at

the time of a crisis or emergency in daily life. The structure constitutes a major binding block of a social mosaic of a community. A study of its pattern can certainly shed light on many other parameters of dynamics in the society as well, which operate independently or jointly with economic or traditional sociocultural parameters.

Since a system of sharp socioeconomic stratification pervades the rural social structure and the social positions and functional roles correspond to it, one is required to look for an appropriate answer outside the orbit of structural functionalism. Again, neither the theory of general systems nor the organic theory of society provides any satisfactory concept to grasp its nuances. Conflict theory, on the other hand, argues coercion and hence aggressive behavior as the basic motif. While the former cannot explain fragmentation and polarization or conflict in society, its focus being to look for a symbiotic balance that implicitly binds the components of its structure to maintain a stable equilibrium, the latter, on the other hand, has no room for equality or symmetry except as a temporary or passing feature in the society. Network theory can capture both.

Background of the Survey

The sources of our social network data are two longitudinal studies undertaken in a typical rain-fed traditional rice-based economy in central West Bengal in India covering 2,697 households in 21 villages in the Md. Bazar Community Development Block of Birbhum district. Since our study was explanatory, we had to go beyond the boundaries of only a survey of these households (HHs). We had included appropriate qualitative methods for collection of supplementary qualitative data, such as case history collection and group discussion as and when required. One study, which may be considered as a sort of baseline study for the purpose, was conducted during 1971–1972 and the other, its follow-up after about 25 years, during 1997–1998. We start by briefly stating the pertinent findings of the 1971–1972 study (for details, see Bandyopadhyay & von Eschen, 1981, 1991).

The majority of the villagers in the study area belonged to Hindu caste (like the Bagdi) or non-Hindu tribal ethnic groups (like the Santal), which were traditionally ascribed low ritual status according to orthodox religious hierarchy. They were occupationally small or marginal farmers, agricultural and other day laborers, sharecroppers, daily workers in roadside tea stalls or garages, hawkers, and so on. The agro-economic situation of the study area at that time was

marked by scarcity of irrigated cultivable land and lack of credit facilities for poor cultivators. Inadequate and irregular supply of agricultural inputs, such as water for irrigation, fertilizers, and high-yield value (HYV) seeds for rice, forced the farmers to remain "resource poor" and rain fed. Lack of road and transport facilities restricted the access to the outside labor market, which in turn pushed down the level of job availability and compelled the laborers to accept quite low wage rates and inimical terms and conditions of employment. Earning by appropriation rather than by production was the thrust of the large land-owning upper-class elite families that dominated these villages at that time. Acute poverty did not permit a considerable section of the villagers to provide for even a meager "two meals a day" for their families throughout the year. Bureaucratic apathy and bias against ordinary villagers, as well as "red tapism" in redressing their grievances, all taken together had further aggravated the condition of their life and living (Bandyopadhyay & von Eschen, 1995).

The negative experiences created a cultural setup of "amoral familism" (Banfield, 1958). Scarcity of access to resources for the villagers except for a few large land-owning elite families of Hindu castes of high ritual status, coupled with the feeling of helplessness about any possibility of changing the course of life and living in the near future, created a "zero-sum" situation. This, in turn, had generated during the past few decades a covert attitude of jealousy and distrust among the villagers, which continued to dampen the motivation for organizing extensive help and cooperation among the common villagers (Bandyopadhyay & von Eschen, 1988). While the upper-class elites were economically resourceful, socially enjoyed high ritual status, and organized mostly in a few large cliques, the commoners in the lower rung in the village remained economically weak, resourceless and dependent on the elites, socially low in status, and among themselves highly fragmented into a large number of small groups or isolates and hence utterly disorganized. Thus, the local power structure was marked by acute polarization in terms of a highly unequal power base in the community. (For a detailed discussion of power bases and potentials of power, see Wrong, 1988.)

Subsequently, since around the mid-1980s, several important official measures of rural development have been implemented. These measures were aimed particularly at the redistribution of resources and democratization of an administrative system facilitating the involvement of the rural poor in it (Bandyopadhyay & von Eschen, 1995). These include measures such as the redistribution of vested land (Patta); registration of sharecroppers and

a Minimum Wages Act for agricultural and other laborers; development of schemes of minor irrigation; easily available bank loans; establishment of *Panchayats*, which looked after the implementation of these measures; development of a total literacy campaign; extension of road and transport connections; implementation of schemes of rural electrification; and so on. Findings of empirical studies undertaken in the district in general as well as in and around our study villages corroborate that these measures have not only ameliorated the economic condition of the rural poor in a noteworthy way but also catalyzed their socio-administrative participatory role (Rao & Bandyopadhyay, 1998).

Central Query

In the context of the above-mentioned changes in the socioeconomic and administrative scenario in the villages, we asked the following question: Evidence indicates that the economic condition of the rural poor has improved, but with the economic and administrative changes, what has happened to the pattern of articulating ties of social relations such as help and support among the villagers? Does it indicate empowerment of the rural poor or at least a sign of alteration in the power structure within the village due to a decrease in its social dependency on those who are at the top of the structure? And that way, can one make a conjecture of an upcoming change in the structure of social power relations in the villages? In this chapter, we show only in a preliminary way how one can infer in that regard from the distribution of ties in social networks. Detailed analysis of analytical measures will be discussed in the subsequent chapter of case studies.

We have chosen to undertake analysis of a social network formed through help and cooperation in the daily life of the villagers because this constitutes an important element in organizing informal social insurance against vulnerabilities faced by the lower rung of the village community in daily life and living. This query thus becomes directly rooted in the theory of social exchange—in the structure of "resource dependencies," imposing an "unequal flow of resources" in social exchanges among different sets of actors (Cook, 1982).

Morphological Characteristics of Ties of Social Networks

We briefly refer to relevant data of one village (e.g., Kabilpur, occasionally abbreviated as K) among the 21 villages studied by Bandyopadhyay and von Eschen. A detailed discussion in this regard is given in Chapters 6 and 7 after

Table 1.1 Distribution of Ties by Purpose

Purpose	*Frequency*	*Number of Ties as %*
Related to medical treatment	289	28.7
Food/related to food	203	20.1
Family rites	161	16.0
Production (mostly farming)	86	8.5
Family crisis (counseling, mediation, or general suggestions)	84	8.3
Miscellaneous	185	18.4
Total	1,008	100.0

Table 1.2 Distribution of Ties by Type of Request

Type	*Frequency*	*Number of Ties as %*
Financial	517	51.29
Material	261	25.89
Physical	230	22.82
Advice/recommendations	173	17.17
Total	1,008	100.00

the mathematical and statistical issues of SNA are discussed in the intervening chapters.

Requests for help, cooperation, and assistance during emergencies in daily life and living still occur in the village despite implementation of various measures of rural development. Informal help and support to meet the urgencies of daily life and living still play an important role in daily village life mostly because the effects of the measures taken for economic development are not yet strong enough for villagers to be able to cope with all kinds of urgent requirements. The data on the distribution of ties of requests for various purposes and types of help made by one household to another in 1997–1998 are given in Tables 1.1 to 1.6.

About half of the requests for help were made in connection with medical treatment and arranging for food in an emergency (Table 1.1). Financial help was the major thrust, although need for material and physical help were also considerable (Table 1.2). The observation that requests for help were also often repeated by one household to another indicated the stability of a behavioral pattern (Table 1.3).

Table 1.3 Number of Times a Household Made Requests to Another During the Past Year

Number	*Frequency*	*Number of Requests as %*
1	537	53.27
2	238	23.61
3	119	11.81
4	39	3.87
5	22	2.18
6	53	5.26
Total	1,008	100.00

Mean = 1.94, standard deviation = 1.36.

Villagers seek help both in cash and in kind. Requests for help in kind are made mostly for rice. The extent of help sought by a household over the year is moderate, but it varies from quite a small amount to a moderately large one, depending on the nature of the problem. Data in this regard are given in Tables 1.4 and 1.5.

Table 1.4 Distribution of Ties by Amount of Monetary Help

Amount (*Rs. in a Year*)	*Number of Ties*	*Number of Ties as %*
Below 100	142	25.7
100 to 250	136	24.6
250 to 500	151	27.3
500 to 1,000	69	12.5
Above 1,000	55	9.9
Total	553	100.0

Mean = Rs. 346.46 and standard deviation = 31.99.

Content of Network Ties

Data on sources of informal help show that these have become more diversified than before. Employers and political elements have been added to kin and friends (the latter dominated the earlier scenario), as shown in Table 1.6. Knowledge and experience have also become objects of sharing

Table 1.5 Distribution of Ties by Quantity of Rice Borrowed

Quantity (*kg in a Year*)	*Number of Ties*	*Number of Ties as %*
Below 20	59	26.6
20 to 60	51	23.0
60 to 200	62	27.9
200 to 500	38	17.1
Above 500	12	5.4
Total	222	100.0

Mean = 79.81 kg and standard deviation = 22.03.

as and when needed. Nowadays, the villagers interact at many more different levels in their ordinary daily life, which has led to the diversification of social relationships along which the ties of request flow. Providing alternative sources of support in case of a crisis or emergency faced in the course of everyday life has no doubt added to the strength of the buffer against vulnerabilities.

An in-depth exploration of meanings attached by actors to the ties of these social relationships, as if untying the knots of a discourse, unfolds a social reality in transition.

The underlying rationale of the bulk of the requests (59.2%) is instrumentally oriented to secure personal gratifications of the partners at both ends. From one end, the sender of the request does it explicitly for financial, material, or physical support at the time of an urgent need. At the other end, the potential giver calculates in terms of the expectation of some sort of future reward in the form of uninterrupted labor supply as in case of an employer (30.2%), creating confidence or extending a support base among the villagers by a political figure (5.0%), or gaining the obligation of the neighbor to provide help in return as and when such a need occurs (24.0%). Incidence of goal-oriented instrumental requests such as to share experience and knowledge whether in social life or material production in exchange of social respectability is low (6.0%). But what is most relevant for the conjecture made earlier concerning social reality is that fulfillment of traditional customs or duties or moral bindings motivates "the other end" to act only in a moderate-size stratum (29.8%) unlike three decades earlier. In other words, on the whole, social relationships now operate much more instrumentally, or perhaps "unrurally."

Table 1.6 Distribution of Ties by Relationship

Relation	*Number of Ties*	*Number of Ties as %*
Employer	304	30.2
Neighbor	243	24.0
Political	51	5.0
Kin	300	29.8
Friend	50	5.0
Knowledgeable/ experienced	60	6.0
Total	1,008	100.0

Findings From SNA of the Village *K*

A significant finding of the SNA is that on average, the number of HHs one can depend on and approach for help of any type at the time of an emergency was 3.6 in 1971–1972, and this later became even smaller at 1.7 during 1998 in village *K*, considering that there were 239 and 472 HHs in the village during the two time periods, respectively.

The second feature is that the pattern of the articulation of ties was predominantly reciprocal earlier but not any longer. The number of reciprocal pairs has decreased sharply from 387 to 46, although the number of HHs has more than doubled. But one can now reach many more households for help indirectly (i.e., through intermediaries). That is, on other considerations, the role of intermediaries has become more important for the villagers to cope with the "crisis situation" and survive. This is evident from the increase in the percentage of reachable pairs from 2.5% to 15.1%. But this seems to have been achieved at a price: The average distance to the reachable household has increased from 1.2 to 5.8 (see Table 1.7).

Note that in Table 1.7, we have used some common graph-theoretic terms as such since their connotations are quite appropriate sociologically. To illustrate: If an HH y can be requested directly (i.e., in one step) by another HH x, then in the pair of HHs xy, y is reachable from x, and the distance of y from x is 1. Again, if x has to go through two or more intermediaries to request y, then also reachable y is from x, but this time the distance of y from x is greater than 1. In fact, if there are different sets of intermediary HHs through whom HH x can approach another HH y, then the smallest number of such steps (i.e.,

Table 1.7 Summary of Data on Some Measures of the Social Networks in 1972 and 1998

Measure	*1972*	*1998*
Number of households	239	432
Number of ties		
within castes	800	366
between castes within village	71	368
going out of village	0	274
Total number of ties	871	1,008
Average out-degree (within village)	3.6	1.7
Number of reciprocal pairs	387	46
Number of isolates (within village ties)	94	40
Number of isolates (all ties)	94	3
Percentage of reachable pairs (directed)	2.5	15.1
Average finite distance (directed)	1.2	5.8
Maximum finite distance (directed)	4	16
Percentage of reachable pairs (undirected)	7.7	78.2
Average finite distance (undirected)	2.3	4.4
Maximum finite distance (undirected)	6	10

the number of steps in the shortest "distance chain") is regarded as a measure of distance of y from x. In short, a "reachable pair" of HHs xy means x can place a request to y, and the "distance" means the minimum number of steps x needs to reach y with the request. Note that in a directed social network the, distance of y from x can be quite different from that of x from y.

The boundaries of ties of help and assistance have also extended in two important dimensions between the two time periods. Requests now cut across caste and village boundaries much more than in the past. A summary of data on some of the measures for social networks in 1972 and 1998 is presented in Table 1.7.

Two Poor Communities in the Village and Changes in Their Networks

In the village K, the Bagdi and the Santal households constitute the bulk of the village poor. Even within this bottom rung of village society, signs of upward occupational mobility under the impact of land reforms and related measures can clearly be discerned. The occupational class composition of these

Table 1.8 Principal Sources of Livelihood of Bagdi and Santal Households

Year	Farm and Nonfarm Laborer		Factory Laborer	Small or Marginal Farmer or Share-cropper	Total
	Employed at the Beck and Call of the Employer	Working on the Basis of Contract (Per Day/Week/ Month or Job, etc.)			
		Bagdi community			
1997–1998	16 (7.88%)	89 (43.84%)	38 (18.72%)	60 (29.56%)	203 (100.00%)
1971–1972	67 (69.79%)	25 (26.04%)	0 (0.00%)	4 (4.17%)	96 (100.00%)
		Santal community			
1997–1998	1 (1.24%)	35 (43.21%)	9 (11.11%)	36 (44.44%)	81 (100.00%)
1971–1972	33 (62.26%)	17 (32.08%)	0 (0.00%)	3 (5.66%)	53 (100.00%)

two communities has notably changed between the two time periods, as shown in Table 1.8. Households belonging to these communities have become mostly small or marginal farmers, agricultural/factory laborers, and sharecroppers. Since minimum daily wage rates and terms and conditions of employment have improved in these occupations, their economic condition has now become better than what it was earlier when they were largely employed as "attached laborers" hired on the basis of terms and conditions that amounted almost to being a bonded laborer of the land owner. We will not go into these aspects since those have been discussed in detail in Bandyopadhyay and von Eschen (1981). Here we only indicate changes in local power centers and in the overall social relational pattern as a result of economic changes using diagrams of social networks for the village as well as for the two communities separately. Comparison of the networks using measures based on different features will be discussed later in Chapter 6.

In Diagram 1 at the end of the book, we show the social network of the Kabilpur village during the 1971–1972 time period. The numbers in the diagram are the serial numbers of the households. To avoid cluttering, the ties in a clique (where everybody is tied both ways with almost everybody else) are not shown. The flow of out-degrees for the village network is listed in a table at

the end of this chapter for ready reference and for use by the interested readers for any reanalysis.

As one can see, the major component of structural configuration in Kabilpur was a hierarchically organized pyramid: one-way ties from a large number of households going upwards to a small clique of seven households who belonged to the large land-owning Hindu Sadgope caste of high ritual status in the village. There were also two other large cliques of high-caste (Sadgope) large- and medium-sized farmers. These two cliques did not have any tie with the others in the village. Factional conflicts in the past pushed them to continue to live like two isolated groups. The rest of the households in the village were fragmented into small connected groups. There were a large number of isolates as well.

In Diagram 2 at the end of the book, we give the networks of the Sadgope households in the 1997–1998 time period. These show how the cliques of high-caste (Sadgope) landed elites of the earlier period got dispersed later into egocentric fragments, connected through intermediaries.

On the other hand, the trend is different for the Bagdis and Santals. Their networks in 1971–1972 and in 1997–1998 are given in Diagrams 3 through 6 at the end of the book. The networks of the earlier period show the predominance of a reciprocally tied but highly fragmented structure of the two communities. How this apparently paradoxical situation, reciprocity with fragmentation, has come to exist is described later in Chapter 6 on case studies.

In the networks of the Bagdi and Santal communities in 1997–1998, one finds how the social network structures of these communities have become connected through asymmetric ties. These are also marked by a few households, forming mini-hubs, with large in-degrees indicating emergence of egocentric power centers. Small in size but vertically tied up mini-pyramid-like structures have appeared among them, showing the rise of power elites from among them.

The alteration in power structure in the village is further substantiated by an examination of the changes in the distribution of in-degrees. If the in-degrees are arranged in decreasing order, all 21 households at the top chunk of the distribution during 1971–1972 were high-caste landed elites (large farmer Sadgopes). By households at the top of the in-degree distribution, we refer to those whose in-degrees exceeded the mean by more than twice the standard deviation. During 1997–1998, there were 16 households at the top of the in-degree distribution. Among them, two belonged to the Bagdi and one each

to the Santal and the Barber (Napit) communities. Three of these four are only marginal farmers-cum-agricultural laborers, and one—the Barber (Napit)—is a small grocery shop owner who was originally a roadside barber. Recent official measures have increased their income and enabled them to save money. At that stage, with the support of the local Panchayat, they secured financial support from the local bank and have been able to purchase land, a pump set for irrigation, and so on and earn more from agriculture. Two of them were among the important organizers of the local peasants movement as well. One was elected vice-president of the local Panchayat. In times of crises, villagers nowadays depend on them for help and support instead of depending on the high-caste landed elites as they used to do earlier.

The findings of SNA raise a critical question for consideration as a matter of future perspective of social transformation. The mini-pyramids and new power centers from within the lower rungs of society and the disintegration of the cliques at the top are certainly a structural shift away from unequal distribution of power in the society. But is it a move toward an egalitarian society? Is this likely to be a truncated shift and the trend to be rather an instance of substitution of old elites by new ones? Or will it continue to move further ahead through some socially conscious goal-oriented checks to transform the society? Only further studies can enable us to answer these questions.

We close this introduction with a display of the flow of out-degrees of the HHs in the entire village of Kabilpur (1971–1972) in case the reader becomes interested in doing any further analysis of SNA data for this village. Serial numbers of the HHs are shown in ascending order and for each such HH, and we indicate the detailed listing of all other HHs at the receiving end of the ties originating at the initial HH. We separate the HH that originates such tie(s) by a colon(:).

Kabilpur (1971–1972) Village Network: Flow of Out-Degrees of the HHs in the Village

[7 : 218, 219]; [8 : 218, 219]; [9 : 218, 219]; [10 : 218, 219]; [11 : 218, 219]; [12 : 218, 219]; [13 : 218, 219]; [14 : 12, 15, 20]; [15 : 12, 14, 20]; [20 : 24, 25, 218, 219], [24 : 2025]; [25 : 20, 24]; [26 : 13, 17, 30, 218]; [27 : 218, 219]; [28 : 49, 210]; [29 : 32, 33, 36]; [32 : 29, 33, 36]; [33 : 29, 32, 36]; [34 : 132]; [36 : 29, 32, 33]; [37 : 218]; [38 : 42, 69]; [40 : 41, 54, 55, 63, 80]; [41 : 54, 55, 63, 80]; [42 : 38, 69]; [49 : 169, 170, 210]; [52 : 56]; [56 : 52]; [57 : 65, 79, 83]; [58 : 83]; [63 : 40, 41, 80]; [64 : 122, 145]; [65 : 57, 79, 83];

[69 : 38, 42]; [70 : 75]; [72 : 78]; [75 : 70, 218]; [76 : 218]; [78 : 72]; [79 : 57, 65, 83];
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[237 : 176, 178, 191, 193, 206, 229, 230, 231, 232, 233, 234, 235, 236]; [238 : 218, 219, 220]

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