the number of transitive patterns in the network" and "[t]hroughout the year, children became increasingly likely to form relationships with the friends of current friends"(Schaefer et al., 67).

Where We Are Now

We began with some simple definitions. A network is a set of nodes and a map showing the relationships between the nodes. The simplest network is a dyad. Relationships in a dyad can be undirected, mutual, or directed. When there is more than one relationship between a pair, such as coworkers and friends, it is called multiplex. Relationships are transitive when what holds for A to B, also holds for B to C. Triads begin to introduce a true social system. Finally, a description of social networks does more than merely list friends or supporters but rather reveals the extent of connections between them.

Socially interesting aspects of networks occur when homophily and propinquity are introduced. Sure, "birds of a feather flock together" but how this phenomenon occurs for individuals and for collectivities and under what circumstances forms the basis of social analysis, whether the subject be friendship patterns, corporate overlap, or international trade. Especially interesting is sorting out feedback and "chicken-and-egg" issues. People become more similar when they hang out together; but they hang out together in the first place because they are similar.

While there are major tendencies for balance in triads, other principles may also be at play. Groups and individuals may strategize to avoid the consequences of balance and try to make friends with enemies. People come together in different foci or social circles in which not everyone is symmetrically related to the others and yet they are a relatively cohesive unit.

Although triads are perhaps the analogue of molecules for networks, there is an even smaller unit—the dyad. Whole networks consist of many dyads—the basic building block of networks with which we began. Each connected triad is, as we have seen, composed of three dyads—within the pair the choices or connections are either reciprocated or not. A further fundamental aspect of a whole network is centrality or popularity. Then there is the density of the whole network: the number of direct connections or ties that exist, divided by the number of possible direct ties. Size is always important. Small groups tend to have high density, whereas large networks, though connected, tend to have low density. The email network of a university may connect all the students and faculty, but most of these are not directly connected so the email network is relatively sparse and has low density. This is typical of large networks. The distribution of reciprocated or unreciprocated dyads, centrality, and overall network density may account for most of the variance in the distribution of triads in human sociability networks (Faust 2007). This brings us directly to a more detailed discussion of whole networks in the next chapter.

3 Basic Network Concepts, Part II

WHOLE SOCIAL NETWORKS

IN THE PREVIOUS section, some basic concepts were introduced about nodes and the relations between pairs and triads. Key concepts that informed the discussion were homophily (the tendency of pairs of nodes to share the same characteristics) and balance (the tendency of the third in a triad to share or have a characteristic that complements the other two). Important as these ideas are, the essence of social network theory and analysis lies in a consideration of an entire network, to which we now turn.

A sociogram, the graph or diagram of a whole network, examples of which were shown in the first chapter, is one way to understand an entire network. As Yogi Berra reputedly said, "You can observe a lot by watching." However, sociograms that contain more than ten nodes are hard to grasp and subject to different interpretations depending on who is "watching." Analytic concepts and methods that account for the entire network and describe and summarize various aspects of it are necessary. *Distributions* of network properties are the first set of key descriptors and include the number of dyads and triads in the network. Other distributions discussed in this chapter include: *Density*, the number of connections contained within the network, and its opposite, *Structural Holes*, a category concerned with the lack of connections. A related concept, *Strength of Weak Ties*, hypothesizes that important things flow from people with whom one has limited connections. *Popularity and Centrality* demonstrate that some nodes have more connections than others and those connections serve as links to other nodes. Other distributions describe the *Distance* across the network between nodes. The radius of distances from any given node is an important descriptor. In terms of people, those nodes

directly connected with a focal node comprise the *Interpersonal Environment*. The number of nodes in an interpersonal environment is related to the key concept of *Small World*, which describes the relatively small distances that link a given node to all the nodes in a given network. *Multiplexity* recognizes that there may be many networks that connect, in different ways, the same nodes. Finally, *Position or Role* is a concept that is not distributional but invokes how nodes relate to other nodes in the network. As will be seen, position is the most traditionally "sociological" of the concepts I will be presenting and serves as a link to the next chapter that takes up how whole networks can be partitioned into coherent segments.

Distributional concepts help illuminate the sociogram that follows. In a much-analyzed example of a small group, anthropologist Wayne Zachary (1977) carefully observed a karate club comprised of 34 members for more than two years. In this example, we are not concerned with how the network came into being but rather the consequences of its structure. The sociogram was drawn by a computer program, Pajek (Nooy, Mrvar, and Batagelj 2005) and presented by White and Harary (2001). It depicts the network of friendships among the club members (figure 3.1).[1]

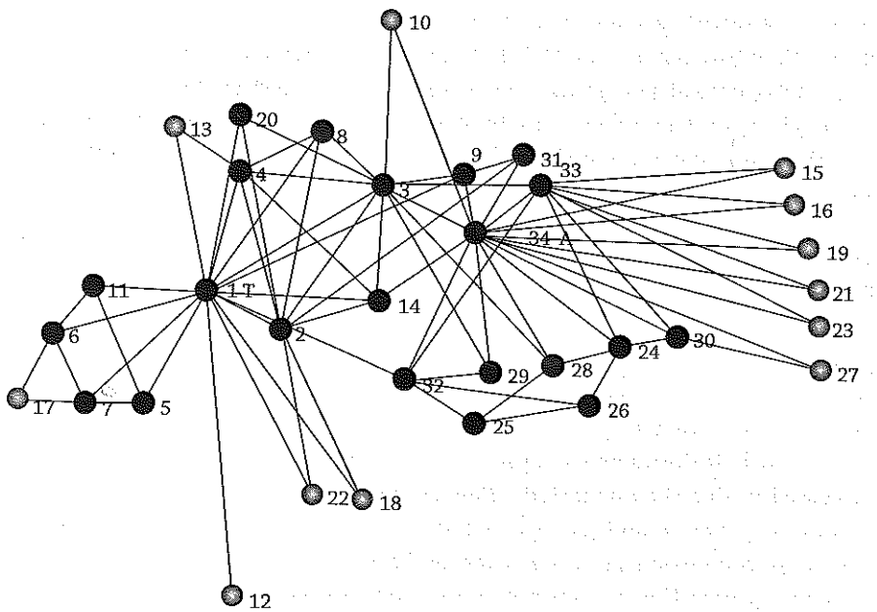

FIGURE 3.1 Friendship Network among Karate Club Members

White, Douglas R., and Frank Harary. 2001. The cohesiveness of blocks in social networks: Node connectivity and conditional density. *Sociological Methodology* 31:305–359, figure 14. Copyright © 2001 John Wiley and Sons, reprinted by permission.

Distributions

DYADS AND TRIADS

In this case, because the graph concerns friendship, it is symmetric: the assumption is that if you are my friend, I am your friend. The connections are based on the observations of the anthropologist and not on the self reports of the members. There are 1,575 symmetric dyads in the network (triad type 3-102 in chapter 2, figure 2). A computer program randomly shuffled the network of 34 people and the 156 symmetric connections between them, called "edges" in graph theory. In each shuffle, the program counted the number of symmetric dyads. The number of dyads was much greater than would have been found by chance. In terms of full triads, club member number 17 on the far left is directly connected with 6 and 7; they constitute a symmetric triad. Another is 6, 7, and 1. Also, 11, 5, and 1 is a symmetric triad. There are 45 such triads in the entire network (triad type 16-300 in chapter 2, figure 2), also far more than expected by chance. The dyads and triads calculations were not made by hand, an effort that would have been tedious and likely to have resulted in many mistakes. Rather, these and later calculations that illustrate distribution concepts in this sociogram, were accomplished by me with a widely used computer program, UCINET 6 (Borgatti, Everett, and Freeman 2004).

DENSITY

Density is defined as the number of *direct* actual connections divided by the number of *possible* direct connections in a network. The karate club network is obviously densely connected. The overall density is 0.139 with 156 connections out of 1,112 possible connections. There seem to be at least two parts to the network—the right side and left side—and within each part the density is obviously greater than the average. We will discuss partitioning a network into "natural" groups in chapter 4.

Density is at the heart of community, social support, and high visibility (when people in a network can see what others are doing and monitor and sanction their behavior). Density facilitates the transmission of ideas, rumors, and diseases. Other things being equal, the greater the density, the more likely is a network to be considered a cohesive community, a source of social support, and an effective transmitter. Classic agricultural communities or villages have greater density than modern cities, and people tend to know one another in many contexts—as relatives, coworkers, church attendees, and so forth. Given the human limitation on the number of sustainable connections, smaller networks will have greater density. It is easier to know everyone in a small group than in a large community. In comparing different networks in terms of density, one therefore has to take into account their size.

STRUCTURAL HOLES

Density is based on the idea of connection. But one can turn the idea on its head and focus on the *lack of a connection* (Burt 1992).

Consider the following network (figure 3.2), which I created to illustrate this point:

There are two obvious clusters: 5, 6, 7 and 2, 3, 4. Each cluster is totally connected, that is, each of their members is said to be structurally equivalent to each other. However, the members' only link to one another is "Ego." Ronald Burt calls the situation in which Ego connects individuals who are themselves connected but who, without the presence of Ego would have no connection with one another, a "structural hole." In the karate club sociogram, nodes 1 and 34 are the key linkers, and their actions are the least constrained by others in the network. The important implications of structural holes and the role of Ego as a "broker" will be considered in greater detail in chapter 5.

WEAK TIES

"The strength of weak ties" is the title of an article by Mark Granovetter (1973) that has achieved almost as much fame and certainly more citations than the more popularly known "small world" described by Stanley Milgram in his *Psychology Today* article (Milgram 1967).[2] Like structural holes, "weak ties" also focuses on holes in the network. The most authoritative statement of the idea is Granovetter's 1982 reprise:

> [O]ur acquaintances ("weak ties") are less likely to be socially involved with one another than are our close friends ("strong ties"). Thus the set of people made up of any individual and his or her acquaintances will constitute a low-density network (one in which many of the possible ties are absent), whereas the set consisting of the same individual and his or her *close* friends will be densely knit (many of the possible lines present).

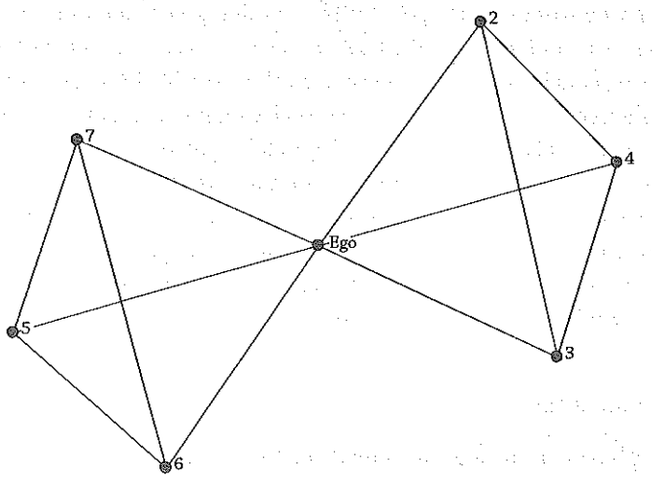

FIGURE 3.2 Example of a Structural Hole

> . . . Ego will have a collection of close friends, most of whom are in touch with one another—a dense "clump" of social structure. Ego will [also] have a collection of acquaintances, few of whom know one another. Each of these acquaintances, however, is likely to have close friends in his or her own right and therefore to be enmeshed in a closely knit clump of social structure, but one different from Ego's . . . These clumps would not . . . be connected with one another at all were it not for the existence of weak ties. (Granovetter 1982, 105–106 [italics in original])

Weak ties have several interesting consequences (Granovetter 1982, 106). First, weak ties facilitate the flow of information from otherwise-distant parts of a network. Individuals with few weak ties will be deprived of information from distant parts of the social system and will be confined to the provincial news and views of their close friends.

Second, weak ties help to integrate social systems. The macroscopic side of this communication argument is that social systems lacking in weak ties will be fragmented and incoherent. New ideas will spread slowly, scientific endeavors will be handicapped, and subgroups that are separated by race, ethnicity, geography, or other characteristics will have difficulty reaching a modus vivendi.

There are various complications to the analysis of weak ties. First, the definition of what constitutes a weak tie or relationship can be somewhat slippery. Is it the length of time one knows someone else, the frequency of interaction, the subjective "closeness" one feels, or whether the others one is connected with are defined as relatives, friends, or acquaintances? Second, it is important to understand that the critical function of weak ties is one of bridges between network segments. As Granovetter puts it, "The importance of weak ties is asserted to be that they are disproportionately likely to be bridges as compared to strong ties, which should be underrepresented in that role. This does not preclude the possibility that most weak ties have no such function" (Granovetter 1982, 130). Third, it must be the case that "(1) something flows through these bridges—they actually serve as conduits bearing information and influence to groups they otherwise would not get, and (2) whatever it is that flows actually plays some important role in the social life of individuals, groups, and societies" (ibid.). A flow can occur only under some circumstances. Passing along information or exercising influence should not be too costly to the weak tie that constitutes the bridge; otherwise, strong ties that are willing to bear the cost will be more effective in making the bridge. For example, if a mere acquaintance knows about a job (the original context of Granovetter's study), and the acquaintance does not need the job himself or herself, then there is little cost in passing along the information. It would take a strong tie to pass along information that might cause a loss to the person passing it along.

"POPULARITY" OR CENTRALITY

Popularity can be broken down into several different ideas—all under the general rubric of "centrality" (Freeman 1979). It is obvious in the karate club that persons 1 and 34 have great centrality. Many lines radiate from them (or go to them, because friendship is reciprocal). The sheer number of connections is called "degree." Person 1

has a degree of 16 and person 34 a degree of 17. When the network is directed (not reciprocal), there is an indegree, number of "votes" received, and an outdegree, number of choices made. Almost all networks have nodes or persons with higher degrees than other members of the networks, whether the topic is friendship or corporate connections to banks.

An interesting variation on the focus on the number of votes is the source of the votes. A node is more popular or powerful if it receives nominations, or indegrees, from nodes that themselves have high degree. The individual or entity is popular among the popular. There are various measures of power or prominence that take this factor into account. In the karate club, while nodes 1 and 34 have the highest degree and the most power, nodes 3 and 33, because they receive nominations from 1 and 34 and others with high degree, also score fairly high on power.

An inspection of the network shows that 1 and 34 are in the middle of things. One can get to other members via these leaders. This is called "betweenness" (Freeman 1979). There are various methods for measuring betweenness, but all are based on the idea of a switching point. The person or organization that serves as a connector or a switching point can be very important, above and beyond their "popularity." In the structural hole diagram, Ego has high betweenness. In the karate club, although 16 and 34 each have almost the same degree, 1 has a higher betweenness score. Node 1 connects the cluster on the extreme left with the rest of the club, making node 1 a bridger or broker.

Centrality has many substantive implications. A classic series of experiments with networks of various shapes showed that "where centrality and hence, independence are evenly distributed, there will be no leader, many errors, high activity, slow organization, and high satisfaction" (Leavitt 1951, 50). On the other hand, when a network was shaped in a "wheel" pattern—so called because individual persons, the spokes, were coordinated by a central person—the organization was efficient, but only the person E in the center of figure 3.3 below had high satisfaction.

DISTANCE

Not only are there many direct connections in the karate club network, but also many indirect ones. For example, 17 is directly connected with 7 and indirectly connected through 7 and 6 to 1 in a second step. While the symmetric dyads and triads are by definition transitive (see chapter 2), it is not assumed that indirect connections, such as between 17 to 1, are transitive. That is, 17 is not necessarily a friend of 1 or 1 a friend of 17. That two-step connection is the shortest connection of 17 with 1. But also, because this is a dense network, 17 can get to 1 in three steps via 5 or via 11. All the nodes are eventually connected with one another through paths of various lengths. The longest path with direct connections is of length 5, and there are 16 of those. For example, 17 to 15: 17 → 7 → 1 → 9 →33 →15. This is a compact network whose average distance is 2.4 paths. Not so incidentally, the computer program that drew the network placed 17 and 15 at opposite sides of the diagram.

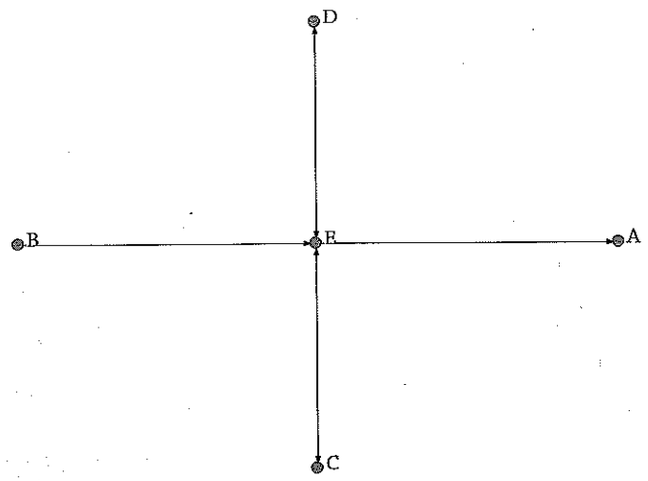

FIGURE 3.3 Example of a Wheel Pattern

Formally, the distance between two nodes is defined as the length of the shortest path via the edges or binary connections between nodes. This is called geodesic distance. Shortest paths are efficient, but there are also consequences to inefficient or redundant paths in which there are many ways to get from one node to another. Redundancy, as noted in connection with density, makes sense in the diffusion of norms, attitudes, or values. One might have to hear the same thing from several different sources until it takes root. Then too, in terms of diffusion, we might want to discount a source that is several steps removed because messages might get garbled as they pass from one node to another that is not transitive. So one might count the first step as important, the next step as less important, and so on. On the other hand, some things, such as computer viruses (not "social" in the human sense), spread unadulterated through many steps.

The set of nodes directly linked to any given node is called the first-order zone (Barnes 1972; Mitchell 1969). The nodes two steps removed from a focal node are called the second-order zone, and so on. When the first-order zone is about individual persons, the term "interpersonal environment" is often used (Rossi 1966; Wallace 1966). In graph theory, this is called the "neighborhood." As will be seen shortly, these interpersonal environments can vary considerably in their size. The friends of the friends in the first-order zone are reached in only two steps. If the first-order zone is large, then many friends of friends can be reached (one of the principles of Facebook). If the friends in the second-order zone are not the same ones as in the first-order zone, then Ego has a large reach indeed. Reach or connectedness (the famous "six degrees of separation") was studied by Milgram in his "small world" experiments (Milgram 1967).

Larger whole networks such as cities or communities would be ideal subjects for the study of distance, popularity, and density. However, we have not been

successful in collecting large-scale network data that would make such an examination feasible. A possible alternative means of getting information about networks is to study members of the first-order zone of a sample of respondents through the use of "name generators" (Wellman 1993). This system produces ego-networks, that is, networks centered about a particular individual. In a widely utilized data set, the General Social Survey in 1985 asked respondents to name up to five others with whom they "discussed important matters." In these types of surveys, information about each of these "others" is sought from the survey respondent on such topics as how they came to know the other, for how long, some of the social attributes of the other, and the extent to which each of the others knew each of those named in the first-order zone (Marsden 2005, 1990). The study might include a number of different name generators, and more than five individuals might be pursued. Although this ego network might seem to be a limited application of network ideas, the data so generated has been extremely powerful and the source of a number of insights into social networks that will be referred to throughout this book. One can measure the density and the social characteristics of the ego's interpersonal environment, that is, the dyadic relationships between ego and each of the persons mentioned. One can also try separately to survey the persons mentioned in a "snowball" technique, thereby moving out a number of steps from ego.

Size of the Interpersonal Environment

The number of individuals in the interpersonal environment or the first-order zone varies from about 100 to 5,000 persons, depending on how it is measured (for example, people you know by name) and the type of society in which the focal person is embedded (Bernard et al. 1989; Killworth et al. 2006; Killworth et al. 1990; Pool and Kochen 1978; Zheng, Salganik, and Gelman 2006).

In general, as we will see, in classic village societies "everyone knows everyone else," so the number of steps from one person to any other is minimal. Village societies are also relatively small and confined so that the first-order zone may be no more than about 500 local persons (Boissevain 1974), thus limiting the number of persons who can be directly reached. In contemporary urban societies, professionals and middle-class people have a larger first-order zone than blue-collar and lower class people (Kadushin and Jones 1992). On the other hand, in these societies there may be serious barriers across class and ethnic lines, making for greater distances between persons in different classes and ethnicities (Wellman 1999a). The issue is a complex one and will be taken up later.

Organizations too have first-order, second-order, and tertiary zones, as suggested by the concept of external economy described in the previous chapter—those aspects of an organization that it relies upon to survive and thrive but which are not formally a part of the organization. The network of part suppliers for automobile manufacturers is part of their external economy, but so is the absorption of the costs of carbon emissions by the rest of society. These matters will be discussed when we come to organizations and overlapping circles.

The "Small World"

If there were no overlap in people's personal networks, then as we suggested in the Introduction, one could reach the entire population of the United States in two or three steps (Pool and Kochen 1978). Suppose everyone in the United States knew 500 other people and that each set of 500 was unique—none of the people you know are known by, say, your brother or sister. Then, each of the 500 people you know in turn knows 500 unique others, and they each know 500 others, and so on (Pool and Kochen 1978, 33). Five hundred people raised to the power of three is 12,500,000, much greater than the size of the U.S. adult population age 18 and over in 1977 (154,776,287).[3]

However, to the extent that the same people are encountered in the interpersonal environment of different nodes, that is, to the extent that personal networks overlap, more steps will be needed to reach the entire population of the United States. Under such circumstances, getting out of one's immediate circle becomes more difficult. Social structure, as Pool and Kochen demonstrated, reduces the number of unique individuals in the iteration of steps; and therefore, the expansion to a large population takes more steps or links. For example, it is more difficult for whites to reach African Americans. This topic will be analyzed when we discuss social circles of individuals.

Despite the theoretical number of two to three steps between any two persons in the United States, experiments done by Stanley Milgram and his students in the 1960s estimated the actual number of steps to be six, reached through five intervening persons (Milgram 1969, 1967; Travers and Milgram 1969), hence the popular phrase, "six degrees of separation."

The alleged "six degrees of separation" does not, however, take account of variation in people's skills at making connections. In Milgram's original experiments, most people were not able or were unwilling to make the requested connections. A recent experiment using the internet found that few of the chains were actually completed and concluded that, although in principle people were connected, the actual successes depended on their motivations and incentives (Dodds, Muhamad, and Watts 2003).

In Milgram's experiments, people were asked to reach a target person in a distant city by means of a person most likely to know the target person on a first-name basis. The experiment worked like a chain letter. The number of steps was higher than the theoretical number because there were social structural barriers to network linkages. In the first experiment, Milgram reported that links between men and women were much less frequent than same-sex linkages, a finding repeated in the recent experiment. Similarly, there were barriers between social classes. Hence, personal agency or motivation became a factor in establishing linkages. Organizations, too, vary in the extent to which they actively seek to relate to other organizations and are skilled in this endeavor.

Multiplexity

Thus far, only single-stranded ties have been formally considered, though we have given some examples of multiple connections. The members of the karate club had

more than one kind of relationship with one another. That is, their relationships were multiplex. The members could relate to one another in eight different contexts such as going to the same classes or hanging out together in a bar across the street from the campus (Zachary 1977, 461). The karate club network depicted earlier reported any relationship originating in any one of the eight settings. The density of the network based on any one relationship would obviously be less than shown above.

In most situations, there are multiple connections between nodes. Multiplexity is related to the concept of homophily discussed in chapter 2, for the bundling of particular kinds of ties is hardly random and follows the laws of homophily of position that we have already discussed. Multiplexity has been used in the network literature in two related senses: one, sometimes called role multiplexity (Beggs, Haines, and Hurlbert 1996), refers to the possibility that two nodes occupy more than one position that ties them together, typically, the situation described earlier in which two nodes have an organizational relationship, say "supervisor" and "assistant" (to the supervisor), but are also friends. Classically, this occurs in village societies in which people are simultaneously kin, workers on the same farm, members of the same religious cult, and the host of shifting roles common to village economies in which tasks are largely filled by part-time specialists in which the blacksmith may also be the head of a clan, the godfather to a number of persons, and a local intellectual sage. Boissevain offers this proposition: "Because the activity fields in this small community overlap and the same actors play different roles to the same audience, we may also expect high multiplexity" (Boissevain 1974, 72). In complex non-village societies, roles may become bundled in a somewhat different way. Merton calls attention to "role sets," the set of relationships that ensue because one occupies a given role (what he calls status), an idea that Rose Coser further elaborates (Coser 1975; Merton 1968b). A school teacher relates to students, parents, a school administrator, the Board of Education, and so on. This is the role set that goes with the status of teacher. This role set can of course be analyzed using the formal tools of network analysis, especially those that work with "ego networks." They may or may not also be multiplexed networks.

The second sense refers to the possibility that, as a result of having a given role relationship, say "coworker," there are a number of different flows between a pair of persons, for example, advice, friendship, and work on common tasks (Lazega and Pattison 1999). This has been called "content multiplexity" (Beggs, Haines, and Hurlbert 1996). Further, the same tie, for example advice, can have a number of different kinds of ideas flowing through it: a solution to a problem, a reformulation of the problem, information about solutions to the problem, reaffirmation of an already identified solution, and the credibility of a proposed solution (Cross, Borgatti, and Parker 2001). Attention here is directed to the different consequences of these multiple flows and how they link or conflict under different circumstances.

The concept of multiplexity has an important place in sociological theory. First, as we have alluded to, other things being equal, multiplexity is arguably an important indicator of the presence of folk or village society forms of organization and even rural-urban difference in modern America.[4] Whether intimate ties can be sustained despite the decline of multiplexity is at the heart of network research that inquires

into the relational health of people that live in modern urban settings (See, for example, Wellman and Haythornthwaite 2002; Wellman et al. 2001; Wellman 1999a, 1979).

Second, given the multiple bases upon which relationships can be formed within a community, multiplexity has an important role in theorizing about economic forms. Padgett shows that over two centuries (1300 to 1500) in Florence, the birthplace of financial capitalism, commercial banking firms were formed on four distinct bases: first on the basis of family and patrilineage, next on the basis of guilds, then on the basis of social class, and in the last period, on the basis of patronage (Padgett 2001; Padgett and Ansell 1993). The extent that access and trust are available to bolster economic relations is a consequence of multiplex relationships of different types. For example, ethnic enclaves have been shown to be advantageous to certain kinds of ethnic businesses in part because of the multiplexity of relationships (Portes and Sensenbrenner 1993). Trust, so established by virtue of the ethnic tie, also has global aspects (Tilly 2007). The effect of ethnic enclaves on labor market outcomes, however, is greater for less skilled workers than for professionals (Edin, Fredriksson, and Åslund 2003). Trust among the French financial elite was bolstered by multiplex relations of party, neighborhood, and friendship (Kadushin 1995).

Third, a very substantial proportion of the literature on organizations is concerned with the relationship between ties based on formal positions in the organization and those based on informal relationships discussed earlier. The consequences of formal and informal modes of relations within organizations hinges on the how these multiplex relations are construed in different settings. Informal relations were first identified as loyalties that impeded production (Homans 1950). Others have found informal relations augment formal relations by facilitating the accomplishment of various tasks (Lazega and Pattison 1999). There can be complex relations between formal and informal relations that encourage mentoring or prevent the acquisition of values appropriate to a given organizational role (Podolny and Baron 1997).

While multiplex relations can be described qualitatively and discursively, and one can often get an intuitive sense of what is involved in multiple relations, more precise characterizations of the consequences and causes of different permutations of ties has proven to be a difficult task. The possible combinations of ties can be quite daunting, and the factors that lead to one sort of tie may not have the same force on another type of tie.[5]

In theory there can be two opposite consequences of multiplexity. Multiple flows between positions as well as multiple simultaneous positions can enhance a relationship and build trust, for example, friendship between supervisor and assistant or between political leaders. On the other hand, depending on the circumstances, the same friendship can create a conflict of interest or even the possibility of fraud (Baker and Falkner 1993). Obviously, much depends on the context, and the context can be structural or cultural or both. Merton's role set theory concentrates on the possible negative consequences of multiple role relations and suggests various ways conflict can be managed or alleviated. But the difficulty of quantitatively testing hypotheses on multiplexity has limited formal theorizing in this extremely interesting field.

Roles and Positions

Thus far, we have developed concepts that involve a distribution of network attributes, such as density or distance, and some of the consequences of these distributions. There is another aspect of whole networks: the type of relationship between nodes. Let us call this relationship a role or a position. There is a classic literature in sociology and anthropology about positions and roles (for example, Linton 1936; Parsons 1951; Merton 1968b), and there are network analogues and equivalents.

In interpersonal environments, there are basically two kinds of relationships. First, there are those that are ordained by the social system with very specific names, typically kinship names such as mother, father, children, aunts, uncles, and cousins, or organizational positions such as boss-worker. These relationships are typically asymmetric. Second, there are those relationships that are more loosely and generically named friend, neighbor, acquaintance, or coworker and are more typically symmetric. The network properties of each named relationship, as opposed to generic relationships, are quite dissimilar and have been studied in very different ways. But both types of relationships lead to puzzles and surprises.

NAMED POSITIONS AND RELATIONSHIPS

As we know, networks always involve at minimum two nodes or positions and a relationship between them. Although this may be confusing, the concept of "role" is often used both for the position as well as for the relationship between positions.[6] Named roles, especially kinship relationships such as "father," generally specify not only the meaning of the position but also the content of the relationship, that is, the mutual obligations and expected behaviors of "father" to other named positions such as "son." Not only do named roles indicate the expected relations with other roles, but also the patterning of other relationships—the expected network past the first-order zone: "Primary roles can be cumulated into chains defining compound roles; for example, the sister of my father's father and the subordinate of my boss' protégée" (White 1963, 1). The logical complications of kin relationships can be quite complex, and formal network mathematics can help to specify the implications of such matters as bilateral cross-cousin marriages in which "one's wife is also both Mother's Brother's and Father's Sister's Daughter" (White 1963, 17). Anthropologists have tended to gather networks of named relationships in almost all of their fieldwork, in part because they can do so with only a limited knowledge of the local language. It is one matter to gather the data about the relationships, and another to understand their implications, as controversies in the literature about the causes and consequences of cross-cousin marriage suggest (Homans and Schneider 1955; Lévi-Strauss 1969; Needham 1962). Named relations are of course far from being the whole story, for anthropologists have gathered massive data about the official names of the positions, but not necessarily systematic data about the actual relationships between the positions.

INFORMAL POSITIONS AND RELATIONSHIPS

We will not enter into the details of kinship analysis and the predictions that can be developed from using network analysis to describe kinship structures mathematically. But the principle illustrated by kinship is the association, or lack of it, between formal named and instituted relationships and those that are "informal" or unanticipated. More generally, almost all network analysis involves at some point comparing the network mandated by culture and the social system to networks created and negotiated by people in the process of trying to manage and work the "system." The so-called "formal system" is contrasted and compared with the "informal system." There are those social scientists who feel this distinction is unwarranted, that everything is negotiated and the relationships and mapping between relationships are entirely created through the process of living. To take this extreme point of view is to deny the weight of tradition and habit, but most of all, to deny that concepts and names have consequences with which people daily struggle.

In *Crime and Custom in Savage Society*, Malinowski (1959 [1926], 70–84) gives a poignant example of the problems of a young man who wanted to marry a woman who was, according to kinship rules, forbidden to him. Because Malinowski spent all of World War I in the Trobriand Islands, and therefore had considerable time to observe the local population, he was able to compare the rules to the way they were actually carried out. "...I found the breach of exogamy—as regards intercourse not marriage—is by no means a rare occurrence, and public opinion is lenient, though decidedly hypocritical" (ibid., 80). While Malinowski observed many examples of the breach of exogamy and "[m]ost of my informants would not only admit but actually did boast about having committed this offence or that of adultery..." this was true only of intercourse not marriage. He was aware of "only two or three cases of marriage within the clan." Nonetheless, these violations did exist.

Informal relations are thus not independent of formally defined or culturally named positions. The informal exists in reference to, or even in opposition to, the formal relationships. It is as if the non-prescribed paths or relationships or exchanges are "draped" upon a scaffolding of the formal relationships. The instituted or prescribed relations are always in some way, even negatively, "taken into account." A good example is formal hierarchy, a feature endemic to organized society.

Informal Relations and Hierarchies

There are network equivalents to power or status positions. Hierarchy in networks can be seen as a transitive tree or pyramid structure as in figure 3.4 below.

The relationships are transitive in a power structure because A can command or instruct B who can command F. A's command of B is binding on F. They are asymmetric because B cannot command or instruct A. The inequality of the three levels in the pyramid—A, B, C, D; and F, E, H, I, J—is exogenous or external to the network (Martin 2009, chapter 6). The inequality may stem from the organization's rules or structure, from a social class system or some other system of ranking. The tree structure as depicted has no horizontal connections—B, C, and D, for example, are not connected,

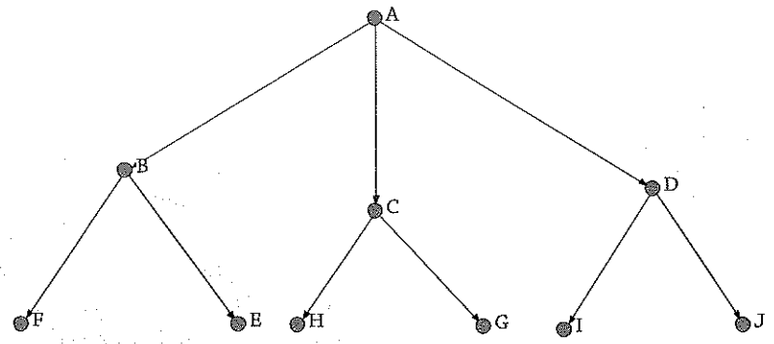

FIGURE 3.4 Example of a Pyramid Structure

and we have shown no other networks in which B, C, and D might also participate. In real-world networks, there are often horizontal connections so that rank or status can "leak" or flow by the principle of homophily—a node can acquire the prestige of those she or he hangs out with, as any social climber knows (Podolny 2005, chapter 2).

Further, in real-world trees there may not be symmetry of command, but there may be symmetry of information because information may flow up and down the levels. Figure 3.4 would look different if information flowed up and down: we would draw arrows at both ends of the lines connecting the nodes.

But formal hierarchy is often not the whole story. In a large manufacturing organization I observed, there were formal hierarchical relationships that defined the positions in the organization—the "organizational chart" similar to the stylized hierarchical chart shown above. When critical decisions were made, individuals often "skipped levels" and enlisted support above the level of their immediate superior. True, this is an "informal system" for making decisions. But the person chosen as the one higher in rank than the one supposedly entrusted with the decision was hardly picked at random. The choice could be predicted from the organizational structure—it did not follow directly from the "rule book" but was surely related to it. Which brings us to the issue of embeddedness.

EMBEDDEDNESS OF THE INFORMAL WITHIN INSTITUTED OR NAMED NETWORKS

All enacted relationships or networks are embedded within formal arrangements. Embeddedness means a number of different things to different students of networks. All agree, however, that networks are influenced by and related to cultural and social structural frameworks. And the converse holds true as well. Information and ideas are affected not only by relations between pairs, but are also responsive to being part of dense networks that amplify and transmit the ideas and the information.

A good example of embeddedness is the constant struggle to determine how power in America actually works. In American national politics, channels for creating legislation are prescribed by law. But certain committee members and lobbyists count for more than others and are the ones who critically determine what a new law is likely to look like. One needs to study all these systems carefully—the kinship, the organizational, and the national legislature—to uncover the informal connections. Nonetheless, these connections are related to the mandates and functions of the formal institutional structure that the informal one elaborates. This is an obvious point, but one which is often neglected when we become entranced by the continuous reenactment and creation of structures.

OBSERVED ROLES

Anthropologists distinguish "emic" and "etic" concepts. Emic ideas are those that "insiders" to a culture use, and "etic" ideas or concepts are those that observers impute to the culture or find useful in describing it.[7] Unnamed positions or roles are those that observers ascribe to a structure which may or may not be so described and noted by the "natives." A "leader" found through network analysis may or may not be recognized as such by the members of the network. The relationships between the individuals and the central role played by the coordinating figure in the "wheel" communications structure described earlier were imposed by the design of the experiment. Yet in the wheel configuration, most experimental subjects, when asked about "the organization of your group," were able to describe it. On the other hand, subjects in other configurations were not able to do so (Leavitt 1951). There is an important literature in the network field that refers to "roles," as discovered through network analysis methods that create partitions of whole networks (White, Boorman, and Breiger 1976). But these partitions are not necessarily defined as normative named roles by the participants in the network. Positions that have "structural similarity," as discovered through network analysis, can be described as occupying a role or a status, though this may not be so noticed or conceptualized by participants in the structure.[8] Partitioning whole networks is a complex topic with many ramifications that will be presented in the next chapter.

Whether or not the roles are emic or etic does, however, have important consequences.

Roles, statuses, or positions that have names are much more likely to have a longer life than roles or positions that have been ascribed to a structure as a result of network analyses. Persons in an organization who occupy a position discovered through network analysis that allows them "structural autonomy"—that is, the ability to act as brokers between persons who otherwise would not be linked (see the karate club example, above)—are not very likely to hold that position a year later (Burt 2002). In contrast, a person who holds a named position is more likely to continue in that position.

To summarize the matter of positions and roles. Network relations can be prescribed by values, organization, and institutions. Often, when relations are prescribed, they are given a name. Relational names are very important in predicting the forms that networks take. But the prescribed relations are only part of the story, since relationships are further elaborated on the base of the prescribed. Under many conditions, the elaborations become instituted and so become prescribed, and another round of elaboration begins. Since most people know the prescriptions, one "charm" of network analysis

occurs when the additional elaborated relationships are revealed. But these revelations are only part of the story. Even the prescribed relationships are sufficiently complex so that participants in society see only the relationships that immediately surround them in the first-order zone and are rarely aware of the implications of second-order zones. Participants are unable to visualize, much less model, the entire system. Networks have been compared with traffic jams—you can see the cars that surround you, but it takes a helicopter to get above the mess and see the entire picture.

Summary

This was our first systematic encounter with the essential subject matter of the book—complete social networks. We began with a small network taken from real life observations—a karate club. We first analyzed it with the help of concepts from the previous chapter: dyads and triads. Besides those concepts, we needed the help of computer programs to draw the sociogram and to carry out the analyses. As one would expect, the club was more "social," cohesive, and clustered than a random network. We knew this because the computer program showed that there were more symmetric dyads and triads (the 300 type in figure 2 in chapter 2) than would have occurred by chance. This was a compact network; the average distance traced from one member to another was only 2.4. And it was a dense network, especially in the two segments of the network. Some members were clearly more popular and better connected than others. The concept of centrality captured the notion of "popularity." Who is "fairest of them all" can be indicated by degree (the number of "votes" a person obtains); power (the number of votes from those who are popular); and betweenness (acting as a switching point between members of the network). The network was dense because it was based on multiplex relations—members encountered one another in a number of different settings because they were part of a community, and communities are characterized by multi-stranded relationships. In fact, multiplex relationships may be one of the hallmarks of traditional communities. Modern societies and large networks in general are less dense and have structural holes, more dense parts of a network that are hardly connected at all; if connected, then it is by nodes that serve as brokers between the otherwise barely connected regions. Large modern world networks are held together by weak ties—relationships that are infrequent, less close and less intimate, but for that very reason very important. Flows through networks are critical and can take place through redundant dense ties or through weak ties.

We considered the number of steps or zones that radiate out of the first-order zone, the area that directly surrounds an individual. This concept leads to the small world idea in which everyone is somehow connected. The number of steps it takes to reach everyone depends on the number of persons in the first-order zone, and the extent to which persons past the first-order zone overlap with others. If there were no overlap, the entire population of the United States could be reached somewhere between two and three steps. As it is, social structure creates barriers so that the number of steps can be far greater.

Positions are a key idea in whole networks. Positions can be socially defined statuses, such as father, son, president, or positions can be defined by the observer through network analysis. Both are often called "roles." Instituted or socially defined statuses themselves form networks; they are generally elaborated upon by informal networks. Positions are sometimes arranged in a hierarchy or a tree. The rules for these hierarchies are generally created by the social system in which they are embedded, though further informal interaction can alter the hierarchies and the rules.

We now turn to the issue of network segmentation, a topic that surfaced earlier in our karate club example.