1 Introduction

"NETWORKING" SEEMS TO be on everyone lips. No one simply goes to a party anymore. They go to network. For many people, the World Wide Web exists for the main purpose of making connections. Networking seems familiar yet mysterious, accessible yet arcane. Social networks, however, have been at the core of human society since we were hunters and gatherers. People were tied together through their relations with one another and their dependence on one another. Tribes, totems, and hierarchies may have come later. Kinship and family relations are social networks. Neighborhoods, villages, and cities are crisscrossed with networks of obligations and relationships. Beyond kinship relations, people in modern societies are dependent upon one another for such things as picking up the mail when one is away, help with fixing the lawn mower, or recommendations for good restaurants. Nonetheless, it is said that urban Americans are becoming more and more socially isolated. The metaphor of "bowling alone," rather than in clubs, leagues, or with friends, describes this picture of isolation and disengagement (Putnam 2000). But rather than disappearing, neighborhood and village-based groups celebrated as the heart of nineteenth-century America have become transformed from social relations and networks based on place or kinship into communities oriented around geographically dispersed social networks.[1] The telephone and automobile started this revolution and were, not surprisingly, popular in rural areas where there were great distances between households. We have been "networkers" for millennia.

Networks are not the same thing as "networking," or actively using a network to make connections to further one's personal goals. A network is simply a set of relations between objects which could be people, organizations, nations, items found in a

Google search, brain cells, or electrical transformers. Transformers do not "network." In this book we are concerned with *social* networks, and what passes through these networks—friendship, love, money, power, ideas, and even disease.

Has the internet, itself an example of a huge network, changed the rules of social networks? Less than has been claimed. Though people's networks contain substantial numbers of friends, neighbors, relatives, and workmates who are locally based, social networks are supplemented by new internet-based media. It is not a matter of one replacing the other; rather, the "internet fits seamlessly with in-person and phone encounters... The more that people see each other in person and talk on the phone, the more they use the internet" (Boase et al. 2006). Social networks are resilient and constantly adapting. Large "mass societies" remain bound by personal ties.

So while the mass media may have "discovered" social networks—a few years ago the *New York Times* celebrated social networks as one the "new ideas" of 2003 (Gertner 2003)—what is relatively new are systematic ways of talking about social networks, depicting them, analyzing them, and showing how they are related to more formal social arrangements such as organizations and governments. In 2008 alone, *Science Citations Index* found 1,269 articles on "social network" or "social networks." In the last 10 years, the total figure is 6,304. The growth is linear. Since 1984, there has also been rapid growth in the number of substantive areas to which social network analysis has been applied, from train schedules in China to the HIV epidemic. The popular press and blogs have been deluged with writing about social networks. Recently, Google listed over 52 million entries for "social networks."

Nonetheless, there is something mysterious about social networks. We live surrounded by them, but usually cannot see more than one step beyond the people we are directly connected to, if that. It is like being stuck in a traffic jam surrounded by cars and trucks. The traffic helicopter can see beyond our immediate surroundings and suggest routes that might extricate us. Network analysis is like that helicopter. It allows us to see beyond our immediate circle.

This book aims to take away some of the mystery about social networks by explaining the big ideas that underlie the social network phenomenon. I concentrate on the concepts, theories, and findings of the social network field. Intended for readers with no or a very limited background in mathematics or computers, this is not a "how to do it" book. There are many useful books that help the reader, often assuming the aid of an instructor, to analyze, deconstruct, and display social networks with the aid of computers. Here I attempt rather to explain the concepts, theories, and findings developed by network experts. Because I am a sociologist, the book has a structural social science bias, but it also takes account of people and their motives. I hope it will be useful to social scientists who encounter social network research in their reading and wish to know more about it and to students new to the network field. I also hope it will be useful to managers, marketers, and others who constantly encounter social networks in their work life. Maybe avid social "networkers" will find it useful. Graphics are important to the network field. So when there is a mathematical basis for network ideas and findings, I try to present them as a graph.

There is a lot to cover, and if the rapid growth of the field is any guide, the coming years will see even more work. There are two contrary trends in any field: investigators build on

the basic work of others and stand on the shoulders of giants (Merton 1993), but at the same time they strive to make previous work obsolete. While recognizing that the social network field is moving swiftly, I attempt to select material that serves as basic building blocks and examples of best practices that will allow the reader to understand and evaluate new developments as they emerge. By the time the reader has finished the book, there may well be important new discoveries in understanding social networks and their myriads of applications. Social network sites are burgeoning systems that in the hands of ordinary people as well as revolutionaries may—or may not—be changing the course of history. Yet sound research on these sites is still in its infancy. My hope is that this book will give you the concepts and ideas to understand research and accounts of developments in social networks that are now almost unimaginable.

A few examples that dramatically capture the current state of the art of the field are the best way to begin to understand what social networks and social network research is all about: getting connected; networks as information maps; leaders and followers; and networks as conduits.

Getting Connected

Everyone could be connected, if only we knew how to reach out beyond our immediate horizons. One of the signs of the growth of the social network field is the very idea of "networking,"[2] especially with the aid of the internet. Making connections through social network sites and the internet is ever increasing. It is not confined to adolescents looking for more friends. As of December 2008, 75% of the U.S. adult population used the internet. Of these, 35% now have a profile on an online social network site, up more than fourfold from 8% in 2005.[3] Seventy-five percent of adults 18 through 24 have a profile and almost 70% of students and teenagers, suggesting that as these cohorts age, the total proportion of the U.S. population using social network sites can only rise.[4] Almost 90% of adults use their online profiles to keep up with friends, and half use it to make new friends. Internet-based social networking is more common among urban dwellers who perhaps might feel otherwise more isolated. Facebook, founded in 2004 as a social networking service for Harvard students, is currently (2010) valued at $50 billion dollars. According to the research firm ComScore's 2009 *Digital Year in Review*, it has surpassed MySpace and attracted 112 million visitors in December 2009, up over 100% during the year. As of July 2010, Facebook claimed 500 million active users worldwide. Twitter, publicly released in August 2006, is a social networking service that enables anyone to post messages of no more than 140 characters, known as tweets, to people who sign up as self-designated followers. ComScore reported 20 million visitors for Twitter in December 2009, up tenfold from the previous year. Google, the leading search engine that aids social networking services, is also based on network ideas first developed for citation analysis in the 1950s. All these sites and services are free to the user.[5]

Social network sites have profound implications. Suppose the number of "friends" you have on your profile is a modest 100. If none of them is a friend of the other, then

two steps removed, you have access to 10,000 people (100 times 100), who can also reach you. Three steps removed there are 1,000,000 (100 times 100 times 100). Soon, the entire world is a potential friend, for better or for worse. No wonder you hear from people who want to be your friend, many of whom you have never before heard from. There is some danger in this, for you may be exposed to more people than you may have desired. The world is indeed "small." The implications for network theory will be expanded upon later in the book in a chapter on the "Small World."

As "social networkers" hope, these connections can be useful. Connections have the potential to give a person access to valuable resources such as: referral to jobs by people out of one's immediate circle who might know of jobs one's close friends are unaware of (Granovetter 1973); ability to rise in the social ladder of occupations (Lin and Erickson 2008a); help with personal problems (Thoits 1995); referral to a good restaurant, book, or movie (Erickson 1996); or someone who can pick up your mail when you are away (Fischer 1982). These networked resources that you do not own, but to which you have access through your friends and acquaintances, are called "social capital" (Mouw 2006).

Networks as Information Maps

Social network analysis reveals what is hidden in plain sight. When you buy a book from Amazon, the site tells you what other books those who bought your selection also bought. I myself have succumbed to this marketing application of networks and bought books I might not have otherwise considered. Using network analysis principles, Valdis Krebs, an organization consultant who specializes in social network applications, exploited the Amazon data to create on his blog[6] a map of books related to the 2008 presidential campaign. Below is his map of books bought by the same people (figure 1.1). The

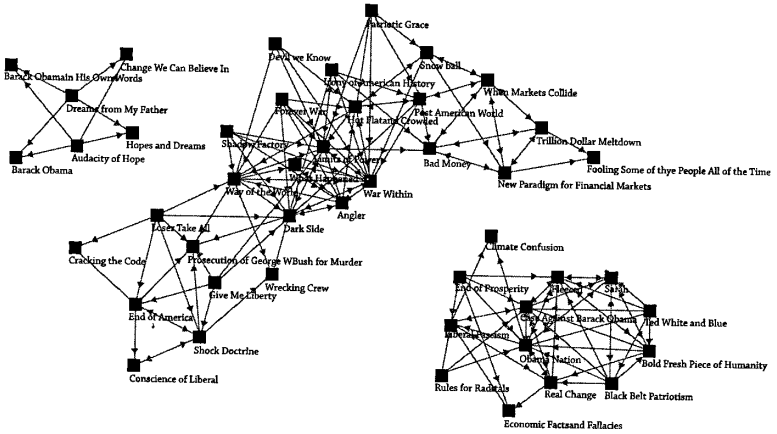

FIGURE 1.1 Books Bought by the Same People in the 2008 Presidential Campaign with the kind permission of Valdis Krebs

arrows show, for example, that people who bought *Dreams from My Father* also bought *Change We Can Believe In*.

There is an Obama cluster of books in the upper left corner; a Democratic campaign cluster in the middle, and a Republican group on the right. There is no overlap between the clusters. In 2008, the reading population of America was polarized, a significant augur for subsequent political polarization. *Rules for Radicals*, by radical community organizer Saul Alinsky, does not fit the partisan tone of the rest of the books in the Republican cluster and was bought by people who bought anti-Democrat and anti-Obama books. One supposes that they wanted to learn about some of the successful grassroots organizing principles of the Left. "Tea Party" organizers?

Network ideas are useful for displaying data such as who bought what book but are especially helpful in making sense of news that involves connections, such as who was involved in what banking deal, who was tied to Madoff's Ponzi scheme, or who was in the network of 9/11 highjackers. Newspapers and Web news sites increasingly use them. Displays of networks on the Web are especially useful because they can be interactive, allowing further information about the points in the network. We can not do this in a book, but figure 1.2, provides an example from *Slate* of the network implied in the Mitchell Report[7] that connected baseball trainers and players involved in providing

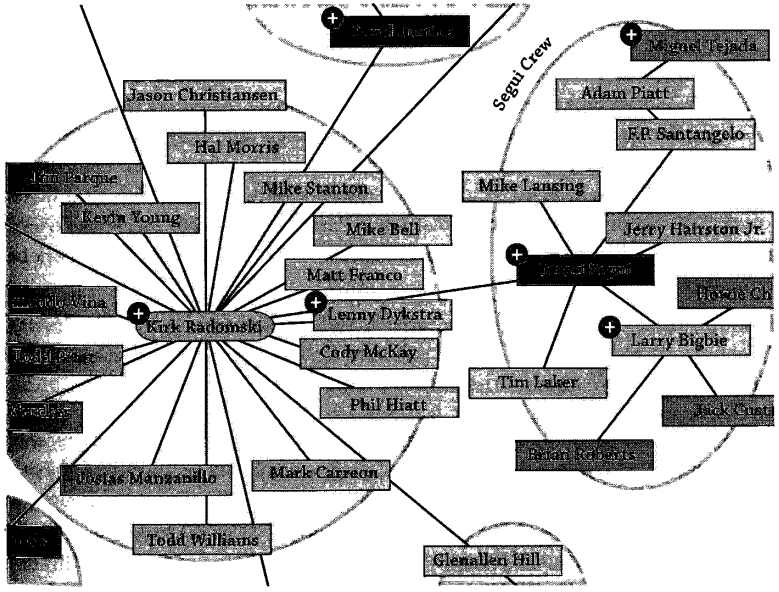

FIGURE 1.2 Detail from a Network Depicting Connections in Performance-Enhancing Drug Usage in Baseball.

With the kind permission of Washingtonpost.newsweek Interactive (WPNI), publisher of Slate Magazine

Slate: The steroids social network. An interactive feature on the Mitchell report. By Adam Perer and Chris Wilson Updated Friday, December 21, 2007, at 11:12 AM ET. The figure is produced by *Social Action* software developed by The Human-Computer Interaction Lab of the University of Maryland.

or using performance-enhancing drugs. The full network diagram gives at a glance the information contained in the lengthy report.

We are all familiar with another kind of network display: the organizational chart that shows who reports to whom and who is responsible for what. One of the earlier applications of social network studies was to discover how workplaces and organizations really worked and what made for leadership. The formal chart cannot possibly account for workplace complexities, and strict adherence to them is usually a recipe for stasis. One of the latest buzzwords in management is "Network Organization," meaning an organization that is explicitly non-hierarchical.

What is a formal organization and what is an informal network has been the subject of a recent Supreme Court case.[8] A man convicted, under federal racketeering laws, of breaking into safe deposit boxes claimed that his loosely organized group was not really an organization under the law. For the majority, upholding the conviction, Justice Alito wrote, "The group need not have a name, regular meetings, dues, established rules and regulations, disciplinary procedures, or induction or initiation ceremonies." The core group was "loosely and informally organized, lacking a leader, hierarchy, or any long-term plan."[9]

Leaders and Followers

Not long ago, Valdis Krebs started to utilize Twitter. Then there was a "denial of service" when Twitter broke down. He began to wonder about the failure of such services as Google, Facebook, and other sites that rely on a single site. They play with what he calls the betweenness paradox. Ultimate control when they work—total failure when they don't. Figure 1.3 from his blog[10] shows a network with a number of obvious failure points. Take out one point, and many others become unconnected. This is also true of covert intelligence and terrorist networks. Take out a key point, and the network becomes ineffective.

Networks as Conduits

Networks are conduits of both wanted and unwanted flows. Physicists who recently became interested in networks, social and other, were intrigued by the rapid failures of the North American electrical power grid leading to massive blackouts. Although the failures were eventually traced to one or two individual electrical transformers, it was determined that the design of the power network caused those failures to cascade into a system-wide breakdown (Watts 2003, 19–24).

Obesity can be an "epidemic." Network magic is no more evident than in the study that shows that over time, obese people are socially connected with other obese people (Christakis and Fowler 2007, 373). Network diagrams covering a period starting from the year 1975 show that the tendency of obese people to be mutually connected

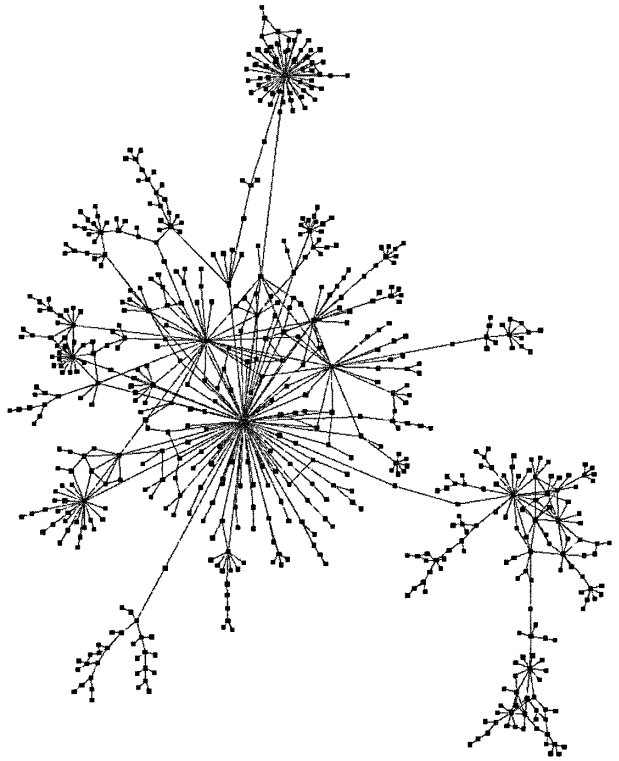

FIGURE 1.3 Kreb's Followers on Twitter. Copyright © Valdis Krebs, with his kind permission

dramatically increases over time. This illustrates two of the major propositions of social networks: homophily—people with like characteristics tend to be connected; and influence—connected people tend to have an effect on one another.[11] The example of body mass is unexpected since that does not appear at first glance to be a social characteristic. But network analysis reveals that it is. These investigators showed, with the same Framingham study, originally intended as a prospective study of how heart and hypertension problems develop, that non-smoking, a "good" attribute, also tends to be contagious.

Marketers are always trying to find ways to reach and persuade individuals in a mass society. Personal contact is most effective, if one can find a way to start a snowball rolling. Borrowing from epidemiology, marketers call this "viral marketing." In the network below (figure 1.4), researchers tracked recommendations for a Japanese graphic novel and illustrated the spread in a dense network. The full story is complicated, and viral marketing does not always work, but the investigators found that

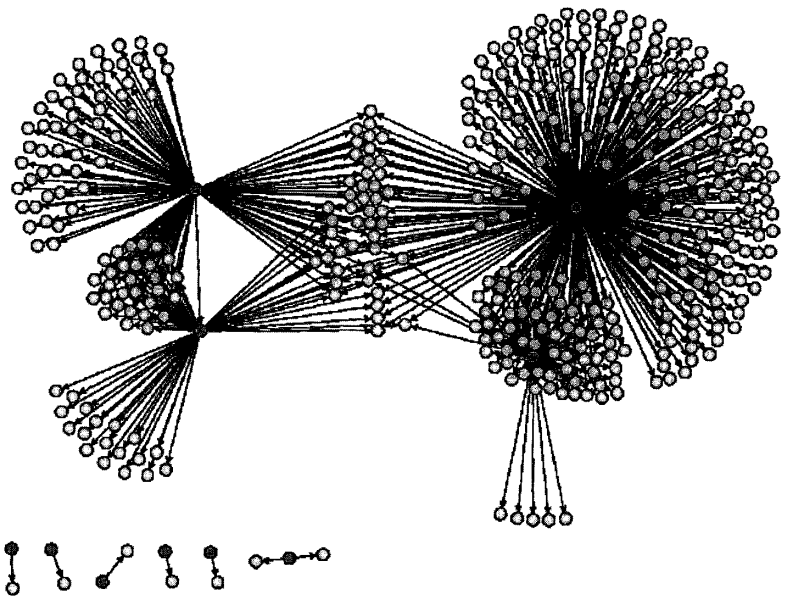

FIGURE 1.4 Personal Recommendation: Viral Marketing for a Japanese Graphic Novel
Jure, Leskovec, A. Adamic Lada, and A. Huberman Bernardo. 2007. The dynamics of viral marketing. *ACM Trans. Web* 1 (1):5 doi>10.1145/1232722.1232727. © 2007 Association for Computing Machinery, Inc. Reprinted by permission.

"personal recommendations are most effective in small, densely connected communities enjoying expensive products" (Jure, Lada, and Bernardo 2007, 36).

You can see how the recommendations for the novel fanned out from a few key points in the network.

The Point of View

I have described just a few striking aspects of social networks. This book seeks more systematically to locate social networks within the general enterprise of social science. The structural point of view in social science sees the patterning of connections as both a cause and a consequence of human behavior: I hang out with people who share my ideas; but by virtue of hanging out with them, my ideas become more and more like their ideas.

This view differs from a purely structural analysis of nonhuman networks. The massive power failures that affected the North American power grid in August 2003 were not a failure of individual transformers but a failure of the very patterning of the power network, that is, a design problem in the way the whole network was structured. Transformers, of course, have no "motivations," though when their functional designed

parameters are exceeded as a result of system overload, they fail and in part become responsible for a blackout.

Human networks are also subject to structural analysis. But there is a difference. Human networks arise as a result of acts by individuals and organizations. The networks created by these acts in turn produce networks that have consequences for individuals and social organizations. Social networks evolve from individuals interacting with one another but produce extended structures that they had not imagined and in fact cannot see. Individual interaction takes place within the context of social statuses, positions, and social institutions, and so social networks are constrained by these factors. The social statuses, positions, and social institutions, however, can themselves be regarded as connected networks. These networks are constantly emerging and as a result affect and change the very institutions and organizations from which they emerged.

Understanding a feedback system requires that one starts somewhere. The book is based on the assumption that social networks begin with people. One could of course argue, as indeed some do, that the network patterning itself produces individual motivation such as status seeking. But we prefer to start with people rather than with large social systems and build up from people and small groups to larger social systems.[12] After explanations of key social network concepts in chapters 2, 3, and 4, chapter 5 deals with the psychological foundations of social networks: people, their motivations to form connections, and the cognitive limitations that affect the size of their social circles. We build on this with chapter 6 on small groups and leadership, which shows how these elementary building blocks draw on basic characteristics of individual motivation. Chapter 7 on organizations shows how patterning in small groups affects the function and structure of organizations. We then move to considering whole social systems. Chapter 8 explains how the "small world" works and its implications. Chapter 9 covers diffusion through networks of artifacts, ideas, attitudes, and disease. Chapter 10 on social capital summarizes some of the utility of social networks as assets analogous to economic capital. In the end, most social network data comes from people. Since there are ethical issues in revealing personal connections, chapter 11 deals the complications and ethics of gathering network data about people. The Coda, chapter 12, sums up the ten master ideas of social networks.

As a rule, we generally eschew explaining a phenomenon by pure patterning and structure. There is a constant feedback between structure and behavior. Because of this feedback, network analysis gives us powerful tools and concepts to unravel matters of concern to classical social theory, though to be sure, this is a work in progress and we have a long way yet to go. Some of the questions that are addressed, though hardly solved, are: What is the relationship between basic personality constructs and social relations? How do groups form? What is the nature and source of leadership? How can we best describe the way social positions relate to one another? What is the nature of authority in organizations and society? What are the ways of constructing efficient organizations that benefit their stakeholders? What is the nature of community, and how are people world-wide related to one another? How do new ideas spread and develop? What are the basic social resources of individuals and societies and how

can they best be utilized? From time to time, we will reference classic social theorists to see to what extent social network ideas illuminate the problems that they posed. In this view, social networks are not only structural abstractions and the study of networks is not an alternative to classic ways of understanding society, but is a way of gaining greater insight into social life. Though networks also characterize the inanimate world such as electrical power grids, social networks have to be understood, to quote E. F. Schumacher (1973), "as if people mattered."

2 Basic Network Concepts, Part I

INDIVIDUAL MEMBERS OF NETWORKS

Introduction

Social network theory is one of the few theories in social science that can be applied to a variety of levels of analysis from small groups to entire global systems. The same powerful concepts work with small groups, with organizations, nations, and international systems.

Chapters 2–4 introduce elementary network concepts, the "score-card" without which you cannot distinguish the players. In addition to defining the concepts, the chapters provide some flavor of how they are used and how they are linked to basic ideas about networks. This chapter introduces concepts concerning relations between the units that comprise a network. Chapter 3 discusses concepts that describe a network as a whole. Chapter 4 addresses where to draw the line—partitioning whole networks. We begin with a definition of a simple network that connects pairs or dyads. We conclude the chapter with a discussion of triads, the most elementary network in which the structure of the network really matters. For networks, dyads and triads are the analogue of molecules. Dyads and triads will give us a handle for understanding larger networks.

With dyads or pairs we are interested in why people come together—why they form a dyad in the first place. As with all network theory, we will see that a feedback loop is at the heart of network processes. There are forces such as propinquity—for example being in the same place at the same time—that bring people together; but at the same time, the dyad creates consequences for its members and for the whole network. People