Theories of Communication Networks

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<1>Dedication

To…The ties that bind, reciprocated with our love, connected forever:

Janet, Todd, Ryan, and Amber

Thrity and Maria

<1>Preface

Though scholarly interest in the concept of networks has existed for more than two centuries (Mattelart, 2000), it has certainly come of age in recent years, particularly in the areas of communication and organizations. Research has increased dramatically, scholarly and popular books abound on network topics, and the management literature is filled with articles offering advice on network issues. Books cover such topics as structural holes (Burt, 1992), strategic alliances (Yoshino & Rangan, 1995), and the network society (Castells, 1996, 2001). Academic journals contain extensive research on interlocking board directorates, corporate alliances, value chains, network organizations, and much more. Popular magazines offer countless articles on the Internet and World Wide Web, corporate Intranets and Extranets, e-commerce, business to business networks, personal and corporate networks, and virtual organizations, to name but a few of many network topics

The ideas for this book have grown out of our collaboration over the past decade on a variety of network research and writing projects. One of these was a chapter for the New Handbook of Organizational Communication (Monge & Contractor, 2001), which we entitled "Emergence of Communication Networks." In organizing that chapter we were taken by the fact that very little published research on communication and organizational networks was motivated by network theories. At the same time, much network research employed some components of social science theories, or utilized the theoretical mechanisms from those theories, to develop and test network hypotheses, though often more implicitly than explicitly. Consequently, we organized that chapter around the social science theories that scholars have used to account for various network

processes in organizations. Like many handbook chapters and review articles written for publication in academic journals, available space severely limits what can be said. Further, we were struck by the fractured nature of the work in this area. The field does not have a coherent, overarching framework for integrating conceptual, theoretical, and empirical work. Consequently, we set out to develop that framework, and the results of those efforts constitute this book.

But, we should be more specific. Our review of the vast network research literature led us to see several problems in current network research. First, though relatively few network studies utilize theories as the basis for formulating research hypotheses, those that do use only single theories. As such, they tend to account for relatively small amounts of network variance. This, of course, contributes to our knowledge of communication networks, but not nearly to the extent that most would like. This observation led us to develop a multitheoretical perspective as a way to help compare and integrate diverse theories and to increase the explanatory power of research efforts.

A second observation regarding the existing literature is the fact that most research is conducted at a single level of analysis, typically the individual or dyad, though sometimes at the entire network level. Rarely are studies conducted that tap multiple network levels. Networks, however, are complex systems composed of components and properties that exist and can be explained at all levels. A full explanation for the particular configuration observed in any specific network is likely to require informative contributions from all levels. Thus, the framework we develop is multilevel as well as multitheoretical. By multilevel we mean all the typical levels within a specific network

at both a given point in time and at earlier points in time. Further, we also include in the framework the other networks to which the focal network may be related, as well as the attributes of people who comprise these networks. This provides a much broader, comprehensive analytic context in which to situate network research than has been available to date.

Third, many contemporary scholars are exploring challenging frontiers in science that are associated with emergent system properties such as complexity (Axelrod, 1997), chaos and catastrophe (Simon, 1996), and coevolution (Kaufmann, 1993; McKelvey, 1997). This view of contemporary science has not percolated very far into the domain of network research. As a consequence, we introduce in this book the complex adaptive systems perspective. We do this via an agent-based modeling framework. We start with a population of people, organizations, or other entities that constitute a network, generically called agents. The agents follow probabilistic rules that may be independent or interconnected. They observe the behavior of other agents to whom they are connected in their local environment and respond to them. As they follow the rules, network structures emerge. Change the rules and/or the interconnections, and the structures change. This is straightforward agent based modeling.

What is unique in our approach is that the rules assigned to agents are derived from the social theories examined in the book. For example, a generative mechanism in theories of collective action applied to network formation is mutuality. A generative mechanism in cognitive balance theories is transitivity. If we create rules for agents based on mutuality, we can create computational models to examine collective action theories of network formation. If we create rules based on transitivity, we can develop

computational models to explore balance theories of networks. And, by developing computational models that provide agents both sets of rules, we could explore both theories together from a multitheoretical perspective.

Fourth, most network analysis is static and cross-sectional. Of course, this observation is not unique to the area of networks as the same observation can be made about most social science research. Nonetheless, those who are interested in finding ways to study network evolution and dynamics must find tools that facilitate that goal. One set of tools to explore coevolutionary dynamics is computational modeling, an emerging field in organizational analysis and the social sciences more broadly (Carley, 1995). In this book we introduce ideas pertaining to the computational modeling of communication networks. By using the *Blanche* computer program we create dynamic simulations of network evolution. We also explain how to use these results to generate interesting hypotheses and to analyze research data.

Finally, we think that it is extremely important to empirically test the ideas and framework presented in this book. Recent developments in network analysis provide highly useful tools to accomplish this. Thus, we describe the p*statistical framework (Crouch & Wasserman, 1998; Waserman & Pattison, 1996) and Pspar computer programs (Seary, 1999; Richards & Seary, 2001) that provide opportunities to examine the various components of multitheoretical, multilevel network data. These techniques can be applied to network data gathered in the empirical world or generated by computer simulation to show the extent to which theoretically derived generative mechanisms function as rules to guide individual behavior that, in turn, creates emergent network structures. If we were to employ multiple theories and multiple rule-generating

mechanisms, the p* analysis techniques and Pspar computer programs would enable us to test the multitheoretical, multilevel framework proposed in this book. Of course, that is a huge task, the subject of considerable future research. Consequently, we present in the book illustrative examples rather than definitive results, which should provide the basis for considerable future work.

The book has ten chapters organized into two major sections and a concluding chapter. The first four chapters provide the theoretical framework for studying communication networks. The second five chapters explore a wide range of social science theories that contain network-relevant generative mechanisms. Chapter ten integrates the two sections.

Chapter 1 provides a general introduction to networks and a preview of the major theories covered in greater detail in the second half of the book. Chapter 2 provides an overview of network concepts and measures and presents the multitheoretical, multilevel framework. Here, we show how different theories imply different network theoretical mechanisms. As a consequence, different theories should generate different network configurations or realizations. We present this framework for individual, dyadic, triadic, group, and global network properties. We also include influence from the same network at earlier points in time and from networks of other relations at the same or earlier points in time. Finally, the framework permits exploration of a wide variety of network participant attributes or traits. Chapter 3 presents our views of networks as complex systems. We employ agent-based models in which agents follow rules. These rules are derived from the social science theories covered in the remainder of the book and hence provide a way to compare and contrast how they operate, individually and together, to

generate emergent structures. Chapter 4 discusses the emerging field of computational organizational modeling. We provide our perspective on how computer simulations can best be used to study network and related phenomena. And, we introduce and describe *Blanche*, an object-oriented, multi-agent network-based simulation modeling environment that can be used to study dynamic network formulations of social science theories.

Chapters 5 to 9 focus on specific families of theories and show how our multitheoretical, multilevel approach can be used to examine their theoretical mechanisms. Chapter 5 explores theories of self-interest and mutual interest (collective action). These include transaction cost economics, public goods theories, as well as Burt's (1992) theory of structural holes. Chapter 6 examines theories of cognition and contagion. Here, we explore balance mechanisms, inoculation theory, semantic networks, and transactive memory theory. Chapter 7 presents exchange and dependency theories. Chapter 8 explores theories of proximity and homophily. Chapter 9 focuses on coevolutionary theory.

Chapter 10 provides an integration of the first 9 chapters. In it we revisit our approach to modeling complex coevolutionary systems. Having examined the separate theories in detail it is possible to see how the different generative mechanisms in the different theories can be used to formulate rules that agents follow in the computer simulations. By returning to the logic of the multitheoretical, multilevel framework, we can see how to test both computer-generated and empirical data to explore the relative contributions of different theories to our understanding of communication networks. We conclude with a number of thoughts and suggestions about future work with the

multitheoretical, multilevel framework, the evolution of complex networks, and the p* analytic strategies.

<1>Acknowledgements

Though as yet you may only have scanned the table of contents, read the preface, or skimmed the chapters, it should come as no surprise that we viewed the process of writing this book as a complex, self-organizing coevolutionary organizational system created out of multilevel heterarchical communication networks. Yet it wasn't until we completed the book and began to think about writing the acknowledgments that we came to fully appreciate how extensive the network of support has been during the years we have worked on this project. A large number of colleagues, family, friends and institutions have shared in almost every aspect of its preparation from early conceptual discussions to the final nuances of production. Some of these contributions greatly influenced the volume you now hold in your hands, leading us in directions we could not have anticipated at the outset.

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Technology and Application." Our work with these colleagues has challenged us to make the arguments presented in this book more sophisticated yet, at the same time, more accessible to a larger inter-disciplinary community of scholars.

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Most books are a creative blend of new ideas and revisions to former thinking. This volume is no exception and we wish to acknowledge former work that we have incorporated herein, both directly and by adaptation. Most important, we thank Sage

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<1>Table of Contents

<1>Foreword

<1>Chapter 1

<1>Networks and Flows in Organizational Communication

Communication networks are the patterns of contact that are created by the flow of messages among communicators through time and space. The concept of message should be understood here in its broadest sense to refer to data, information, knowledge, images, symbols and any other symbolic forms that can move from one point in a network to another or can be co-created by network members. These networks take many forms in contemporary organizations, including personal contact networks, flows of information within and between groups, strategic alliances among firms, and global network organizations, to name but a few. This book offers a new multitheoretical, multilevel perspective that integrates the theoretical mechanisms that theorists and researchers have proposed to explain the creation, maintenance, dissolution, and recreation of these diverse and complex intra- and interorganizational networks (Monge & Contractor, 2001). This focus provides an important new alternative to earlier reviews of empirical literature, organized on the basis of antecedents and outcomes (Monge & Eisenberg, 1987) or research themes within organizational behavior (Krackhardt & Brass, 1994).

Although examining the emergence of communication networks is in itself an intellectually intriguing enterprise, the inexorable dynamics of globalization provide an even more compelling impetus for communication researchers and practitioners (Held, McGrew, Goldblatt, & Perraton, 1999). This chapter begins by underscoring the rationale for studying the emergence of communication networks and flows in a global world. The chapter also situates the contributions of this book in previous communication

perspectives on formal and emergent communication networks in organizations as well as current philosophical perspectives on the study of emergence in structures.

<1>Communication Networks and Flows in a Global World

Communication networks and the organizational forms of the 21st century are undergoing rapid and dramatic changes (Fulk & DeSanctis, 1999). What is unfolding before our collective gaze is being driven by spectacular advances and convergences in computer and communication technology and by the collective economic, political, societal, cultural, and communicative processes collectively known as globalization (Grossberg, 1998; Monge, 1998; Robertson, 1992; Stohl, 2001; Waters, 1995). While many of the changes brought about by globalization are beneficial to humankind, others are clearly detrimental (Scholte, 2000). Key to the changing organizational landscape is the emergence of network forms of organization (Monge, 1995) as an integral part of the coevolution of the new "network society" (Castells, 1996). These organizational and social forms, which are neither classical markets nor traditional hierarchies (Powell, 1990), nor both (Piore & Sabel, 1984), are built around material and symbolic flows that link people and objects both locally and globally without regard for traditional national, institutional, or organizational boundaries.

The emphasis here is on the flow as well as the form. In fact, Appadurai (1990) theorizes globalization as a series of five flows that he calls "scapes:" ethnoscape, technoscape, finanscape, mediascape, and ideoscape. These represent the movements of peoples, technologies, finance capital, entertainment, and ideology/politics through global networks. Thus, capital, material, labor, messages and symbols circulate through suppliers, producers, customers, strategic partners, governing agencies, and affiliates to

form what Hall (1990) calls the "global postmodern culture" (p. 29), one that is simultaneously global and local. Built on the basis of flexible, dynamic, ephemeral relations, these network flows constitute the bulk of organizational activity (Monge & Fulk, 1999). Thus, global organizations are processes, not places.

Globalization processes are fundamentally altering our perceptions of time and space. Harvey (1989) points to *space-time compression* where both time and space collapse on each other as instantaneous communication obliterates the time it takes for messages to traverse space. Scholte (2000) discusses a fundamental change in the social geography such the people inhabit supraterritorial spaces that transcend specific locals. Giddens (1984) articulates *space-time distanciation*, a process by which social relations…or in our case, organizational communication relations…are stretched across space and time, making them more abstract and remote.

Historically, organizations were organized by place, that is, by locale, and "when" was associated with "where." Organizations were established at specific locations, and events tended to occur in the particular locations where organizations existed. As early communication technology enabled people to communication at a distance, organizations came to be organized by time (Beniger, 1986). Today, at the dawn of the new millennium, communication technology makes it possible for people to experience the same event at the same time anywhere in the world (O'Hara-Devereaux & Johansen, 1994). Distance no long matters, and time shrinks space. Communication and computer technologies have merged to generate "virtual organizations" so that people at a distance can work as if they were in the same space at the same time (DeSanctis & Monge, 1999).

As virtual organizational forms proliferate, the virtual will become "real," in that it will be seen as the natural and accepted way to organize (DeSanctis and Monge, 1999).

Castells (1996) points to the emergence of “timeless time,” a phenomenon which is created by hypertext and other new multimedia features, like hyperlinks, message permutations, and image manipulations, that destroy what was historically perceived as the natural sequence and time ordering of events (p. 462). These communication forms alter the way organizations, people, and the rest of the world are experienced. As Castells says “All messages of all kinds become enclosed in the medium, because the medium has become so comprehensive, so diversified, so malleable, that it absorbs in the same multimedia text the whole of human experience, past, present, and future…” (p. 373). These dramatic changes in time, space, and virtual experiences are likely to intensify in the coming decades as communication technologies continue to converge. These are processes we need to understand.

Granovetter (1985, 1992) chastised organizational scholars for failing to see organizations as *embedded* in the network of larger social processes, which they influence and which also influence them, particularly those that generate trust and discourage malfeasance. But as important as Granovetter's arguments have been, they tell only one side of the story. In contrast, Giddens (1984, 1991, 2000) applies the concept of embeddedness to the processes of globalization. He and a number of other scholars have argued that people and organizations around the globe have traditionally been focused on their local networks rather than global contexts. People tend to be more embedded in home, neighborhood, community, and organizational networks in their hometowns, states, and countries than they are in distant connections around the globe.

But, Giddens argues, the processes of globalization are changing this. Specifically, they are leading to *disembedding*, the process by which traditional network ties are broken. Equally important, globalization leads people to establish new ties at a distance through a process of *reembedding*, thus restructuring the world and shifting the focus from the local to the global. In some cases, others argue, these new ties at a distance can restructure and strengthen local diasporas (Tsgarousianou, Tambini, & Brian, 1998). For organizations, too, disembedding is important because it generates restructuring processes, new networks and connections with distant organizational communities around the world. Communication plays a central role in these embedding and disembedding processes as it provides the information, knowledge, and motivation that enable people to envision alternative relations. How these processes work will be central to our understanding of 21st century organizations.

Another aspect of globalization is *reflexivity*, a "deepening of the self" which provides opportunities for new forms of personal relations and participation in new kinds of communication networks (Lash & Urry, 1994, p. 31). As communication technology conveys news, information, and entertainment about organizational and societal processes around the globe, people become more informed about the world, themselves, and their place in the larger scheme of things. These identity-altering experiences include processes of *individuation*, whereby people come to rely less on traditional norms, values, and institutions and more on their own knowledge of things (Giddens, 1991; Lash & Urry, 1994). This leads to individualized patterns of consumption and mass customization of products, both important challenges for future organizations. It also changes the nature of work expectations and experiences, as well as affiliations within a

wide range of social, political, religious, and recreational organizations. Thus, over the next decades we are likely to see substantial global transformations in the ways in which people view themselves, in how they relate to organizations, and in what they are willing to tolerate (Held, McGrew, Goldblatt & Perraton, 1999).

One early manifestation of these changes is the development of "e-lancers," that is, electronically connected freelancers, people who work together on a temporary basis to produce goods and services (Malone & Laubacher, 1998). This new breed of worker brokers their services on the open market, see themselves as transients, and have little if any loyalty or commitment to the organizations for which they work. Instead, their loyalty is invested in their craft. Indeed, Internet websites like guru.com thrive by connecting e-lancers with each other and with contract projects.

Another manifestation of these global transformations is the emergence of the disposable workforce, "people who have several years of skills development and tenure with a firm who lose their jobs through no fault of their own and cannot find comparable employment elsewhere." (Conrad & Poole,1997, p. 582.) From a network perspective, these are people who have had their organizational ties severed, who are floating unconnected in the workforce, and who must establish new connections in order to survive economically. These are people who have been disembbeded by their workday world and who seek reembedding. Both of these examples are a long way from the world of long-term tenured university professors or the Japanese corporate model of life-long employment.

If the phenomenon we take as our stock in trade, organizational communication, is itself undergoing radical transformation, then we too must change our ways of studying

it. And to be effective, the ways in which we change must reflect the transformations that we seek to understand. Since the nature of organizations is radically changing in the 21st century we will need to abandon former notions of what constitutes organizations and explore new possibilities… among them, networks of flows and connections, perhaps even rhizomes (Eisenberg, Monge, Poole, et al, 2000) …irrespective of traditional names, charters, boundaries, or walls. We must transcend our disciplinary parochialism in favor of incorporating insights from other perspectives not normally included in our analytic frameworks, including economics, philosophy, political science, new forms of systems thinking like co-evolutionary, complexity, and self-organizing systems theories, and many others.

Finally, we must recognize that globalization is producing as many if not more negative outcomes than positive ones. We must incorporate in our work explicit attention to problems generated by globalization, including the displacement of labor, the exploitation of child workers, the migration of work forces, the degradation of the environment, and many other important problems. With all this and much more ahead of us, the 21st century should be a most interesting and challenging time to study communication networks and flows within and among organizations. The following section situates the arguments of this book within the context of previous communication research on formal and emergent networks.

<1>Formal versus Emergent Networks

Historically, organizational communication scholars have made important theoretical and empirical distinctions between formal and emergent networks. Theoretically, the notion of "emergent network" was a designation that originally

differentiated informal, naturally occurring networks from formal, imposed, or "mandated" networks (Aldrich, 1976), the latter of which represented the legitimate authority of the organization and were typically reflected by the organizational chart. The formal networks were presumed to also represent the channels of communication through which orders were transmitted downward and information was transmitted upward (Weber, 1947). Early organizational theorists were aware that the formal organizational structure failed to capture many of the important aspects of communication in organizations and discussed the importance of informal communication and the grapevine (Follett, 1924; Barnard, 1938). Several scholars developed ways to study the grapevine and informal networks such as Davis' (1953) Episodic Communication in Channels of Organizations (ECCO) analysis, a technique for tracing the person-to-person diffusion of rumors and the flow of other information in an organization.

Fukuyama (1999) argues that social and organizational structure spans a continuum that ranges from formal to informal. He says, "No one would deny that social order is often created hierarchically. But it is useful to see that order can emerge from a spectrum of sources that extends from hierarchical and centralized types of authority, to the completely decentralized and spontaneous interactions of individuals." (p. 146). Researchers have provided considerable evidence over the years for the coexistence of the two networks. For example, using a variant of ECCO analysis, Stevenson and Gilly (1991) found that managers tended to forward problems to personal contacts rather than to formally designated problem solvers, thus bypassing the formal network. Similarly, Albrecht and Ropp (1984) discovered that "Workers were more likely to report talking

about new ideas with those colleagues with whom they also discussed work and personal matters, rather than necessarily following prescribed channels based upon hierarchical role relationships" (p. 3). Stevenson (1990) argued that the influence of formal organizational structure on the emergent structure could be best understood on the basis of a status differential model. In a study of a public transit agency, he found evidence that the social distance across the hierarchy reduced the level of communication between higher- and lower-level employees, with middle-level employees serving as a buffer.

An important rationale for studying emergent communication networks has evolved out of the inconclusive findings relating formal organizational structure to organizational behavior (Johnson, 1992, 1993; also see McPhee & Poole, 2001). Jablin's (1987) review of the empirical research on formal organizational structures pointed to the inconclusive nature of studies involving structural variables such as hierarchy, size, differentiation, and formalization. More recently, a series of meta-analytic studies have concluded that the relationships between formal structure, organizational effectiveness (Doty, Glick, & Huber, 1993; Huber, Miller, & Glick, 1990), and technology (Miller, Glick, Wang, & Huber, 1991) are largely an artifact of methodological designs. The fact that formal structural variables have failed to provide much explanatory power has led several scholars to question the utility of further research on formal structures. Rather, they have argued that it is preferable to study emergent structures because they better contribute to our understanding of organizational behavior (Bacharach & Lawler, 1980; Krackhardt & Hanson, 1993; Krikorian, Seibold, & Goode, 1997; Roberts & O'Reilly, 1978; Roethlisberger & Dickson, 1939).

A creative alternative to abandoning formal networks in favor of studying emergent ones is to find new ways to examine both. The problems with formal structures have prompted some scholars to develop network measures that capture in emergent networks the key concepts used to describe formal organizational structure. For example, Krackhardt (1994) has developed four measures of informal structure -- connectedness, hierarchy, efficiency, and least-upper-boundedness (unity-of-command) -- that map onto theories of an organization's formal organizational structure.

Further, the increased use of new computer-mediated communication systems has spawned research that uses formal organizational structure as a benchmark against which to compare emergent communication networks, for example, those that emerge in an electronic medium. Several interesting, though somewhat conflicting, findings have been generated. In a 2-year study of over 800 members of an R&D organization, Eveland and Bikson (1987) found that electronic mail served to augment, and in some cases complement, formal structures. On the other hand, Bizot, Smith and Hill (1991) found that electronic communication patterns corresponded closely to the formal organizational structures in a traditionally hierarchical R&D organization. However, Rice (1994a) found that the electronic communication structures initially mirrored formal organizational structures, but these similarities diminished over time. Hinds and Kiesler (1995) explored the relationship between formal and informal networks in a telecommunications company. They found that communication technologies were increasingly used as a tool for lateral communication across formal organizational boundaries; this finding was most pronounced for technical workers. Lievrouw and Carley (1991) argued that new

communication technologies might usher in a new era of “telescience” by offering alternatives to the traditional organizational structures in universities and industry.

The literature comparing face-to-face or mediated emergent communication structures to formal structures generally demonstrates a “pro-emergent bias.” That is, the theory and empirical evidence focus on the advantages of informal communication to individuals and organizations. However, Kadushin and Brimm (1990) challenged the assumption that three types of emergent networks, (a) the shadow networks (the "real" way things get done), (b) the social interaction networks, and (c) the career networks (the venue for so-called "networking") always serve to augment the limitations of the organization's formal network. Instead, they argued that these three informal networks frequently work at cross-purposes, thereby restricting rather than promoting the organization's interests. In a study of senior executives in a large international high technology company, they found that by saying, "Please network, but don't you dare bypass authority," organizations create what Bateson (1972) called a "double bind," a choice situation where each alternative conflicts with the others. They argued that "an important first step is to recognize the incompatibilities between emergent network structures and corporate authority structures and to move this inconsistency from the realm of double bind to the domain of paradox (Kadushin & Brimm, 1990, p. 15)."

Clearly, scholars continue to be interested in the study of the differences between formal and emergent networks in organizations. Ironically, however, the distinction between formal and informal structures in organizations has diminished significantly in recent years and may become increasingly irrelevant in coming decades. The reasons for this convergence center on shifts in organizational structure and management philosophy.

Prominent among these are changes to more team-based forms of organizing, the adoption of matrix forms of organizational structure (Burns & Wholey, 1993), and shifts to network forms of organizing (Miles & Snow, 1986, 1992, 1995; Monge, 1995). At the core of these changes has been the explosion of lateral forms of communication (Galbraith, 1977, 1995) made possible by new information technologies that facilitate considerable point-to-point and broadcast communication without regard for traditional hierarchy (Fulk & DeSanctis, 1999).

These developments have eroded the distinction between prior structural categories used to characterize organizations, specifically, between formal and informal and/or between formal and emergent. Contrary to traditional views, contemporary organizations are increasingly constructed out of emergent communication linkages, linkages that are ephemeral in that they are formed, maintained, broken, and reformed with considerable ease (Palmer, Friedland, & Singh, 1986). As Krackhardt (1994) says, "An inherent principle of the interactive form is that networks of relations span across the entire organization, unimpeded by preordained formal structures and fluid enough to adapt to immediate technological demands. These relations can be multiple and complex. But one characteristic they share is that they *emerge* in the organization, they are not preplanned" (p. 218, italics in the original). The networks that emerge by these processes and the organizations they create are called network organizational forms.

<2>The Emergence of Structure from Chaos

The concept of emergence represents a complex and intricate set of beliefs about how order appears out of randomness in nature and society. As such, it has attracted considerable interest in the physical and social sciences as well as philosophy (Dyson,

1997; Gell-Mann, 1994; Holland, 1995, 1998). In the context of organizations, McKelvey (1997) defines emergence as "any order, structure, or pattern appearing in complex random events that cannot be attributed to some specific prepensive purposeful activity or decision by some identifiable official or unofficial component entity" (p. 359).

Emergence typically refers to a set of arguments that higher-level phenomena appear to exhibit properties that are not revealed at lower levels. Clearly, notions of level and by implication, the notion of multi-level systems, are an integral part of the concept of emergence. Kontopoulos (1994) argues that differences in inter-level orderings reflect the nature of different types of emergent structures. As shown in Figure 1.1, levels may be nested or non-nested. Nesting implies that lower levels are at least partially included in higher levels. Nested structures may be fully nested as in the case of hierarchies, or partially nested, as in the case of heterarchies, also called "tangled composite structures" (p. 55, see also, Hofstadter, 1979; McCulloch, 1945, 1965).

Figure 1.1 goes about here

Tangledness refers to the fact that relations between levels lead to overlapping structures. Tangledness typically produces considerably more autonomy and complexity at each level than the non-overlapping relations found in hierarchies. For example, based on the well-worn notion of a “unitary chain of command,” people in organizational hierarchies report to one and only one boss, each of whom also reports to one and only one boss throughout the organization, which makes for clear-cut and unambiguous lines of authority. People in heterarchies, such as the "matrix” form of organization, typically

report to multiple bosses, who also report to several bosses. This tangled composite form of structure is considerably more complex and autonomous than the simple, fully nested hierarchy. Finally, two types of hierarchies are differentiated. The first is the p-type hierarchy (named after Howard Pattee who formulated early principles of hierarchy) that operates on the basis of strong control principles from the top down. The second is the s-type (named after Herbert Simon, who pioneered the logics of emergent structures), which operates on the basis of a weaker principle of modularity from the bottom up (Kontopoulos, 1994, p. 54-55).

The notion of emergence also raises questions regarding which levels determine other levels. Microdetermination occurs when the lower level parts influence the behavior of the higher levels. Macrodetermination occurs when the higher levels determine the behavior of the lower level parts. Of course, other possibilities exist. Each level could determine the other in equal or differential amounts. Or, neither level could determine the other, in which case, each might be determined by externalities, which are other processes outside of the structure and its parts, which impact one or more levels of the structure. And, finally, we must permit the possibility of each level causing itself via feedback loops over time and via self-organizing processes. As shown in Figure 1.2 heterarchies permit all of these forms of influence. In fact, adequate accounts of the emergence of networks are likely to require some degree of all of them.

Figure 1.2 goes about here

Holland (1997) argues that one major theme runs through the various notions of emergence: "…in each case there is a procedure for freely generating possibilities, coupled to a set of constraints that limit those possibilities." (p. 122). One example is neural networks. In this case, Holland says, "we have the possible ranges of behavior of individual neurons (firing rates) constrained by their connections to other neurons" (p. 122-123, see also Cilliers, 1998). Holland extends this view by arguing that all emergent social behavior can be accounted for by a general algorithm in which the interactions between agents is determined by the inputs to each and the set of rules that constrain possible reactions. He calls this algorithm "constrained generating procedures." We will have more to say about this strategy in Chapter 3.

Emergence implies the idea of incorporation. As Kontopoulos (1994) says, "A dominant, higher, emergent structure appears, subsuming fully or partially various previous modes of organization. This new structure re-organizes the possibility space, the resources and the processes, sets a new boundary for the emergent structure on the basis of which new laws and properties may appear, and ecologically asserts its new-found unity. This amounts to what Pattee and Polayni have called a new closure property that operates as a new law of organization, the logic of the emergent structure" (p. 39).

Kontopolous' (1993) identifies five different epistemic positions on emergence. These views comprise alternative ways of conceiving of structural emergence. The five consist of three forms of emergence that can be arrayed on a continuum that is anchored on one end by "reductionism" or upward determinism and at the other by "holism" or downward determinism. Philosophers have debated these two polar positions since the

early Greeks. It is the three intermediary positions that have emerged during the last half of the twentieth century as alternatives to the two traditional positions.

The first position is *reductionism* in which all of the elemental parts of a system are aggregated into higher-level structures. An aphorism that captures the essence of reductionism states that "the whole is equal to the sum of its parts." Emergence refers to the fact that the collection shows properties not shown by the individual elements. The collective phenomena show '"synchronized aggregation,' that is, formation of higher collective quasi-entities exhibiting novel properties and new stabilities" (Kontopolous, 1994, P. 26). Reductionism also implies that higher levels of structure are completely determined by the lower levels. (Reductionism also refers to the epistemic belief that all observable phenomena, and therefore all knowledge, ultimately can be explained by the laws of physics, that is, reduced to the behavior of elementary particles. Thus, society can be reduced to psychology; psychology can be reduced to biology, biology to chemistry and chemistry to physics. This view has been thoroughly discredited. See Holland, 1998)

The second view is *construction or compositional emergence*. This epistemic strategy contains a partial microdeterminism but also includes a focus on "relational-interactional and contextual-ecological variables." (p. 12). This is a form of microdeterminism in which the parts and their interactions comprise the structure of the larger system. Holland (1995, 1998) argues that the interaction of a large number of agents following a small number of rules can generate highly complex macro-structures. Hofstadter's (1979) description of the behavior of ant colonies provides one classic example. The behavior of individual ants follows about a dozen rules, yet the structure

and behavior of the entire colony is highly complex (Wilson, 1971). Thus, the emergent structure depends in important ways on the relationships that exist among the parts as well as the context of external variables.

Heterarchy is the third conception of emergence. Heterarchies are "tangled composite structures" which have multiple overlapping, relations across levels. To use McKelvey's (1997) terms, heterarchies represent "multiple orders" (p. 355) that are determined by multiple other levels. Rather than being determined solely from the bottom up as in compositional models, or from the top down, as in hierarchies, heterarchical levels codetermine each other. Heterarchies operate on the basis of "partial determination from below, partial determination from above, partial focal-level determination, (and) residual global indeterminacy…. This is possible by virtue of the fact that heterarchies involve multiple access, multiple linkages, and multiple determinations" (Kontopoulos, 1994, p 55). McKelvey (1997) points out that this multiple determination makes heterarchies more complex than hierarchies, and therefore, these multiple orders may be difficult to trace. To illustrate this problem, he provides the example of a division manager who wishes to introduce structural "reengineering" processes into a firm. Resistance to the change can stem from subordinates or superiors, thus crossing three levels, and making identification of emergence more difficult than in a simple top down hierarchy or bottom up reductionism.

The fourth view of emergence is hierarchy. As shown in Figure 1.1, hierarchies are largely (fully) nested structures, which means that higher levels include lower levels. In hierarchies, the microparts are partially overdetermined by the higher levels. Everyone is familiar with traditional organizational authority hierarchies, where each person reports

to one and only one boss. All bosses have authority over all bosses below them in the hierarchy, thus subsuming their authority. The top boss has authority over all. Hierarchy is the dominant form of civil, religious, and other forms of bureaucracy. In organizational networks, hierarchies frequently represent the formal organizational structure.

The anchor on the continuum is holism, sometimes also called transcendence, which constitutes a strong downward determination of the microparts by the macrosystem. Holism is sometimes summarized by the aphorism that "the whole is greater than the sum of its parts." This view emphasizes the totality of the structure, the autonomy of higher levels of structure from lower levels, and the macrodetermination of the parts of the structure by the total structure. In network analysis, holism would emphasize that the overall organizational structure is independent of the particular people who comprise the network. It would also focus on the ways in which the network structure imposes constraints on the behaviors of individuals in the network.

<2>Emergence and Time

Emergence can be viewed from two perspectives with regard to time. *Synchronous* emergence refers to the fact that at any given point in time it is possible to examine both the parts of the network and the entire cross-level structure and see properties such as stability and modularity at one level that do not exist at other levels. Synchronous emergence could show both the parts and their associated network configurations as well as the entire network restraining the behavior of the parts. Diachronic emergence refers to the fact that the behavior of the system over time generates properties at one or more levels that did not exist at prior points in time.

Diachronic emergence provides much more interesting views of the dynamics of network emergence because it reveals a much greater portion of the emergent process than the synchronic perspective (See Monge and Kalman, 1996, for a further discussion of sequentiality, simultaneity, and synchronicity).

This section has introduced, in the abstract, key concepts and epistemic perspectives associated with the notion of emergence. In order to relate these abstractions to the emergence of organizational networks, the next two sections review the genesis of network forms in organizational contexts as well as the perspectives that have been used historically to study the emergence of structure in organizations. Following that review, we overview several families of multi-level theories and theoretical mechanisms that can be used to examine the implications of emergent structure.

<1>Network and Organizational Forms

Communication network patterns that recur in multiple settings are called *network forms*. An early theoretical paper by Bavelas (1948) based on Lewin's (1936) Psychological Field Theory identified a number of small group communication network forms in organizations, including the chain, circle, wheel, and "comcon" (*com*pletely *con*nected), and theorized about how the different forms processed information. These network forms varied in the degree to which they were centralized, with the wheel being the most centralized, since all links centered on one individual, and the comcon the least centralized, since everyone was connected to everyone else and thus had the same number of links.

This theoretical article and an imaginative experimental design created by Leavitt (1951) generated hundreds of published articles over some twenty-five years. The

primary focus of these efforts was the impact of information processing via the different network forms on productivity and satisfaction. (See Shaw, 1964, for a review of this literature). Two prominent findings emerged from this research. First, centralized organizations were more efficient for routine tasks while decentralized networks were more efficient for tasks that required creativity and collaborative problem solving. Second, people in decentralized organizations were more satisfied with the work processes than people in centralized organizations, with the exception in the latter case that the central person in centralized networks was extremely satisfied. Unfortunately, little further theoretical development accompanied this plethora of empirical research. As a result, this line of inquiry has essentially died; almost no articles have been published on small group network forms in organizations during the past twenty years.

Organizational structures, including communication networks that share common features or patterns across a large number of organizations, are called *organizational forms* (McKelvey, 1982). Weber (1947) argued that bureaucracy was the universal organizational form. Three principle theoretical mechanisms that created bureaucracy were rationalization, differentiation, and integration. Rationalization occurred by specifying legitimating instructions that produced standard operating procedures, thus leaving little opportunity for individual autonomy. Rationalizing the network meant specifying who could say what to whom, often summarized by the injunction that commands should flow downward and information upward in the bureaucracy. Differentiation was the process of breaking work up into its various components. This often led to job specialization particularly as production processes proliferated and increased in size and complexity. As work became differentiated, the various parts

needed to be coordinated, and thus processes of integration came into operation. Weber argued that bureaucracy differentiated along vertical organizational lines and primarily integrated that way as well. Bureaucracy allowed little room for lateral, cross-level, or cross-boundary communication networks, i.e., informal or emergent networks, a feature for which it has been frequently criticized (Galbraith, 1977; Heckscher, 1994).

Miles and Snow (1986, 1992) identified four major organizational forms that have developed over the past century. These are: (a) the traditional functional form, which emerged during the early part of the century, (b) the divisional (or multidivisional) form, which was begun by Alfred P. Sloan at General Motors in the 1940s (See Chandler, 1977), (c) the matrix form, which evolved during the 1960s and 1970s, and (d) the network form, which has emerged over the past decade. Miles and Snow (1992) argue that each of these forms contains its own operating logic, or in terms of this book, its own theoretical mechanism.

The functional form uses a logic of "centrally coordinated specialization" (p. 58) which enables it to efficiently produce a limited set of standardized goods or services for a stable, relatively unchanging market. The divisional form operates by a logic of "divisional autonomy with centrally controlled performance evaluation and resource allocation" (p. 60). Divisions produce separate products or focus on separate markets but are collectively accountable to centralized authority through their communication networks. The ability to develop new divisions enables the multidivisional form to pursue new opportunities in changing markets. The matrix form combines the operating logic of functional and multidivisional forms, using the functional form to produce standardized goods and services and the shared resources of the multidivisional form to

explore new opportunities via project groups or teams. The network form uses flexible, dynamic communication linkages to connect and reconnect multiple organizations into new entities that can create products or services.

<1>Three Historical Perspectives on Emergence of Structure in Organizations

Communication network analysis falls within the intellectual lineage of structural analysis, which has had a long and distinguished history. In sociology, Herbert Spencer (1982) and Emile Durkheim (1989/1964) are often credited with introducing structural concepts into sociological thinking. In anthropology, Radcliff-Brown (1959) incorporated structural-functionalist ideas into his watershed analysis of cultures. And in linguistics, structural thinking can be traced to the pioneering work of de Saussure (1916/1966). Most structural analyses of organizations and communication can be located in one of three traditions: (1) positional, (2) relational, and (3) cultural.

The *positional* tradition is rooted in the classical work of Max Weber (1947), Talcott Parsons (1951), and George Homans (1958). Organizational structure is viewed as a pattern of relations among positions. Sets of organizational roles are associated with positions and specify designated behaviors and obligatory relations incumbent upon the people who assume the positions. The positions and attached roles constitute the relatively stable and enduring structure of the organization independent of the people who fulfill the roles. This tradition leads to the view that positions and roles determine who communicates with whom, and, consequently, the communication structure of the organization. White, Boorman, and Breiger (1976) and Burt (1982) have developed the most significant recent positional theories applicable to organizational communication under the rubric of structural equivalence. This theory argues that people maintain

attitudes, values, and beliefs consistent with their organizational positions irrespective of the amount of communication that they have with others in their organizational networks. The positional tradition has been criticized for its inability to take into account the active part individuals play in creating and shaping organizational structure (Coleman, 1973; Nadel, 1957; White, Boorman, & Breiger, 1976).

The *relational* tradition focuses primarily on the direct communication that establishes and maintains communication linkages. Taken collectively, these linkages create an emergent communication structure that connects different people and groups in the organization irrespective of their formal positions or roles. Rooted in systems theory (Bateson, 1972; Buckley, 1967; and Watzlavick, Beavin, & Jackson, 1966), the relational tradition emphasizes the dynamic, constantly changing, enacted nature of structure created by repetitive patterns of person-to-person message flow. Rogers and Kincaid (1981) claim that it is the dominant tradition for studying communication in organizations.

The *cultural* tradition examines symbols, meanings, and interpretations of messages transmitted though communication networks. As part of the resurgence of interest in organizational culture (Frost, Moore, Louis, Lundberg & Martin, 1985), much of the work has been based on Giddens' (1976, 1984) writings on structuration, which attempt to account for both the creative and constraining aspects of social structure. These studies are characterized by an explicit concern for the continual production and reproduction of meaning through communication, examining simultaneously how meanings emerge from interaction and how they act to constrain subsequent interaction. The cultural tradition has spawned recent work on semantic networks (Monge &

Eisenberg, 1987) described later in this book. These three traditions are discussed in greater detail in Monge and Eisenberg (1987).

Although interesting and useful, these network traditions focus attention at a meta-theoretical level and fail to specify the *theoretical mechanisms*, such as self-interest, contagion, and exchange, which describe how people, groups, and organizations forge, maintain, and dissolve linkages. As such, the three network traditions demonstrate an unfortunate bias towards the consequences of network structures on attitudes and behavior rather than generating a better understanding of how and why people create, maintain, dissolve, and reconstitute network linkages. Further, while a number of scholars over the past decade have called for greater explication of network theory (e.g., Rogers, 1987; Salancik, 1995; Wellman, 1988), almost none have provided it. Finally, while several reviewers have identified theories that are applicable to network research within and between organizations, (Galaskiewicz, 1985; Grandori & Soda, 1995; Mizruchi & Galaskiewicz, 1994; Smith, Carroll, & Ashford, 1995) few have systematically explored the theories and their theoretical mechanisms (Monge & Contractor, 2001).

This book addresses these issues in four ways. First, if provides a new theoretical framework that incorporates multiple theoretical mechanisms to generate network configurations. Second, it offers agent-based models of rule following behavior that incorporate theoretical mechanisms for generating complex adaptive networks. Third, it shows how computational modeling, and in particular the *Blanche* computer simulation, can be useful for exploring the evolutionary dynamics of networks. Finally, it reviews new developments in network analysis that permit direct estimation of network

parameters of multitheoretical, multilevel models, thus facilitating empirical exploration of multitheoretical explanations of the dynamics of communication networks.

In the next section we provide a brief overview of the theoretical framework. In the following section we provide a synopsis of the different families of theories that provide the basis for the multitheoretical, multilevel model.

<1>Overview of the Theoretical Framework

Chapter 2 describes the new framework, which we call the MultiTheoretical MultiLevel model (MTML). We argue that alternative social science theories make differential predictions about communication networks. Some of the theoretical mechanisms are unique, even complementary. Others are duplicative, at least in part. Still others compete, offering contradictory explanations. None of the theories, on their own, provide definitive, exhaustive explanations of network phenomena. The MTML framework identifies network properties such as mutuality and density and shows how these properties correspond to theoretical mechanisms in social science theories. We argue that utilizing multiple theories should improve our explanations of network evolution as well as significantly increase the amount of variance accounted for by these theoretical mechanisms.

Since networks are inherently multi-level, the MTML framework identifies network properties that exist at individual, dyad, clique, and network levels. Further, it expands this perspective to include the same network at earlier points in time as well as other networks to which it might be related, both contemporaneously and historically. Finally, the framework permits incorporation of attributes of the nodes at all relevant

levels. This provides a much more general framework for examining the evolution of communication networks than existing alternatives.

Chapter 3 presents an agent-based rule-guided model of complex networks. When agents follow rules complex structures emerge. This process need not be planned in advance; it can be self-organizing. The key that ties agent-based models to the MTML framework is to make the rules correspond to the generative mechanisms of social science theories. We argue and show that models built on the different theoretical mechanisms inherent in different social science theories lead to different emergent structures. Since some of these are complementary and others are overlapping in their explanatory value, we argue that a multitheoretical perspective will improve our explanations and our explained variance.

Chapter 4 focuses on the role of computational modeling in network research. We introduce *Blanche*, a program specifically designed to model the emergence of communication networks. We also discuss the role that computer simulations can play in exploring the dynamics and evolution of communication networks. Computational models enable us to incorporate theoretical mechanisms from social science theories as the rules that agents follow. As agents follow different rules, different structures evolve over time.

<1>Overview of the Families of Theories

The second section of the book focuses on the role of theory and theoretical mechanisms in explaining the emergence and evolution of communication networks. This review demonstrates that a wide array of theories can be used to develop network formulations. In some cases different theories, some using similar theoretical

mechanisms, offer similar explanations but at different levels of analysis. The five epistemic perspectives on the emergence of structure from chaos, reviewed earlier, provide a useful context in which to integrate the heterarchical ordering of multi-theoretical explanations. The review also underscores the considerable variation in the depth of conceptual development and empirical research across the different theories and theoretical mechanisms. Since the book focuses on theoretical mechanisms, many other interesting network articles that have little or no bearing on these issues have not been included. The theories and their theoretical mechanisms are summarized in Table 1.1. These families are briefly summarized in the following paragraphs.

Table 1.1 goes about here

Chapter 5 presents theories of self-interest and theories of collective action. *Theories of self-interest* focus on how people make choices that favor their personal preferences and desires. Two primary theories in this area are the theory of social capital and transaction cost economics. Distinct from human capital, which describes individual personal characteristics, social capital focuses on the properties of the communication networks in which people are embedded. Structural holes in the network provide people opportunities to invest their information, communication, and other social resources in the expectation of reaping profits. Transaction cost economics examines the information and communication costs involved in market and organizational transactions as well as ways in which to minimize these costs. Network forms of organization provide an alternative to markets and hierarchy, which focuses on embeddedness in complex

networks. Information flows are essential in determining to whom a firm should link and joint value maximization offers an alternative principle to minimizing transaction costs.

Theories of mutual interest and collective action examine how coordinated activity produces outcomes unattainable by individual action. One theory that exemplifies this perspective is public goods theory, which examines the communication strategies that enable organizers to induce members of a collective to contribute their resources to the realization of a public good. Mutual self-interest often conflicts with the individual self-interests of the members of a collective and sometimes leads to free riding and other social and communication dilemmas. Network relations are often essential to the provision and maintenance of the good.

Chapter 6 discusses Contagion and Cognition theories. *Contagion theories* address questions pertaining to the spread of ideas, messages, attitudes, and beliefs through some form of direct contact. Contagion theories are based on a disease metaphor, where exposure to communication messages leads to "contamination." Inoculation theory provides strategies that can be used to prevent contamination. Two competing contagion mechanisms have received considerable attention in the research literature. Contagion by cohesion implies that people are influenced by direct contact with others in their communication networks. Contagion by structural equivalence suggests that those who have similar structural patterns of relationships within the network are more likely to influence one another. Social information processing (social influence) theory suggests that the attitudes and beliefs of people become similar to those of the others in their communication networks. Social cognitive theory and institutional

theory posit that mimetic processes lead to contagion, whereby people and institutions imitate the practices of those in their relevant networks.

Cognitive theories explore the role that meaning, knowledge, and perceptions play in communication networks. *Semantic networks* are created on the basis of shared message content and similarity in interpretation and understanding. A complementary perspective views interorganizational networks as *structures of knowledge*. Creating interorganizational alliances requires building extensive knowledge networks among prospective partners and maintaining them among current partners. These knowledge networks are the mechanisms though which organizations share both explicit and tacit knowledge. *Cognitive communication structures* represent the perceptions that people have about their communication networks, that is, about who in their networks talk to whom. These individual cognitive communication networks can be aggregated to provide a collective or consensual view of the entire network. Cognitive consistency theory examines the extent to which the attitudes, beliefs, opinions and values of network members are governed by a drive toward consistency. The theory suggests that network members tend toward cognitive similarity as a function of the cognitive balance in their networks rather than alternative mechanisms such as contagion.

Transactive memory systems consist of knowledge networks in which people assume responsibility for mastery among various aspects of a larger knowledge domain. In this way the collective is more knowledgeable than any component. Knowledge repositories linked to the larger knowledge network facilitate knowledge storage and processing. While knowledge flow is essential to an effective knowledge network,

communication dilemmas sometimes lead people to withhold potentially useful information.

Chapter 7 focuses on *Exchange and dependency theories*. These theories seek to explain the emergence of communication networks on the basis of the distribution of information and material resources across the members of a network. People seek what they need from others while giving what others also seek. The exchange form of this family of theories is based largely on equality, assuming that giving and getting generally balances out across the network. The dependency form emphasizes inequality and focuses on how those who are resource rich in the network tend to dominate those who are resource poor. Consequently, power, control, trust, and ethical behavior are central issues to both theories. Exchange and dependency theories have both been used to examine the flow of information and the power dependencies that develop under interlocking corporate boards of directors. Exchange theory also partially accounts for the emergence of network forms of organization.

Chapter 8 discusses *homophily and proximity theories*. These account for network emergence on the basis of the similarity of network members' traits as well as their similarity of place. Traits represent a variety of personal and demographic characteristics such as age, gender, race, professional interests, etc. Social comparison theory suggests that people feel discomfort when they compare themselves to others who are different because they have a natural desire to affiliate with those who are like themselves. Of course, this ignores the old adage that opposites attract, which would argue for a heterophily mechanism. Proximity theories argue that people communicate most frequently with those to whom they are physically closest. The theory of electronic

propinquity extends this to the realm of email, telephones and other forms of electronic communication.

Chapter 9 explores *coevolutionary theory*. Traditional evolutionary theory is based on mechanisms of variation, selection, retention, and struggle or competition. Random or planned variations in organizational traits occur, which are selected and retained on the basis of their contribution to organizational fitness and survival. Coevolutionary theory articulates how communities of organizational populations linked by intra-and-interpopulation networks compete and cooperate with each other for scare resources. In order to survive, firms must adapt to the constantly changing environmental niches in which they find themselves while also attempting to influence the ways in which their environments change.

The tenth and final chapter of the book integrates the four major contributions of the book. We begin with a review of the essential arguments advanced in this book in terms of the MTML framework and the theories discussed in chapters 5 through 9. We then discuss recent developments in "small world" research. This is an interesting and surprisingly common property where networks display considerable local connectedness while also having a low degree of separation with the other nodes in the network. Next. we discuss an agenda for future research on the emergence and evolution of organizational communication networks. We offer a number of suggestions for areas that need exploration and for the confluence of analytic strategies that could significantly advance our knowledge of network processes and novel forms of organizing in the 21st century. We also offer a number of practical implications for the various theories examined in the book as well as suggestions that managers can use in applying these

concepts to understand and design their organizational networks. Finally, we return to the theme of globalization discussed earlier in this chapter to explore the implications of networks and flows for the globalizing world of the 21st century.