**Assessing the Structural Development & Propagation of Information
In Natural Communication Processes**

Introduction

Organizational communications continue to increase in complexity as physical boundaries disappear and digital channels convey a large component of day to day business information. The diverse nature of information in multicultural populations adds complexity to the transmission and interpretation of messages transported across extensive communication networks. With this increase in complexity, traditional methods used to gather and share information have become unreliable as the accuracy and security of transmitted messages are challenged.

The need to understand and predict the propagation of information in organizational communication networks has become tantamount in private and public sectors and particularly in critical government operations. Organizations are now challenged with developing workable strategies that harness various forms of information to utilize a collective knowledge base and promote predictable decision outcomes. Because communication networks are complex structures, a comparable approach to modeling information processes is needed to define factors behind the acquisition and sharing of information.

In an organizational setting, an abundance of information is typically available from a variety of data sources. The inability to manage an overflow of information can overwhelm traditional communication processes and result in fragmented information structures that misdirect the actions of people and undermine the effectiveness of decision makers. Diversity in information characteristics (i.e., the specificity of information in time and space) and distortions in information (i.e., breakdowns in the quality and availability of information as influenced by source and type) are inherent in traditional communication processes. Strategies to initiate acts of terrorism such as the 9/11 attacks (NCTA, 2004) and the Virginia Tech incident[1] are commonly undetected due to breakdowns in communications that occur when effective strategies are not applied to utilize information that naturally propagates through multicultural and diverse populations. Considering such incidents, the need exists to better understand the propagation of information and define key factors that influence communication processes that subsequently affect outcomes in decision making.

Research Questions
Organizational decision making is influenced by many factors, including adaptations in communications processes that occur through diversity in populations and natural constraints posed by resource, informational, and human limitations. With this in mind, the questions considered in this research are, *"What natural factors influence communication processes in multicultural populations?"* and, *"What mediums facilitate the exchange and propagation of information in diverse, complex communication*

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[1] Report of the Virginia Tech Review Panel,
http://www.governor.virginia.gov/TempContent/techPanelReport.cfm

environments?" The actions and interactions of people and processes create information structures which occur within a natural set of conditions or situational context. As such, structure and process are related and can change the quality of communications in response to shifts in context. Therefore, information characteristics and conditions moderate the structural development of information, thus altering the effectiveness of communication processes and resulting decision outcomes.

The following conceptual model considers these factors.
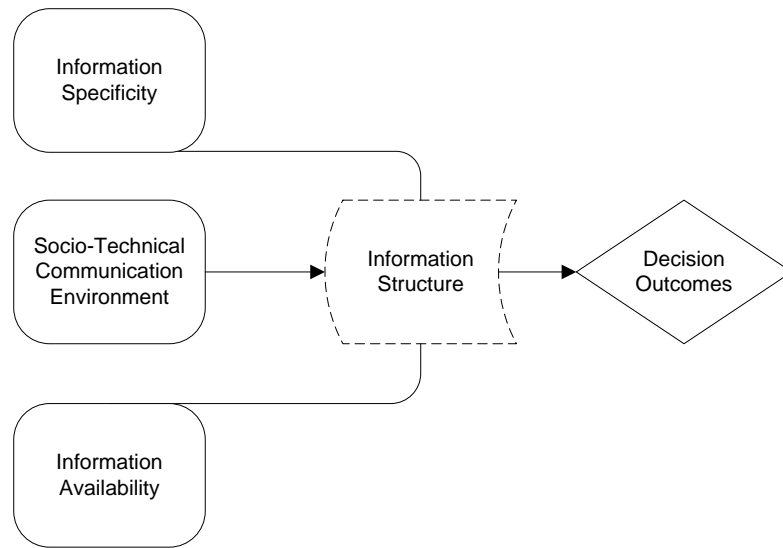
Figure 1: Conceptual Model of Relationships in the Communications Environment

Research Challenges

The first challenge is to better understand the components and structure of information in the communication environment. How individuals and organizations acquire relevant information is tied to their ability to filter information, i.e., the ability to discern relevant or specific information from a large amount of data made available. Therefore, a biblical approach to communications is used to define this environment and to identify factors that influence the acquisition of relevant and highly specific information sources.

The second challenge is to understand how conditions of suboptimal information develop and how resulting information structures impact decision making outcomes. Information can be structured to establish group as well as individual goals which can directly influence the organization of groups as effective decision making units. With this in mind, human groups are classified according to whether a group goal exists and

according to the relationship between the group goal and the need to share communications.

Because a major contribution of this research is to provide insight into the functional design of information systems that are robust to conditions that hinder the acquisition and distribution of critical communications, this research specifically investigates the development of suboptimal structures in complex, multicultural populations.

A theory-driven approach is used to identify opportunities to develop mediums of exchange that facilitate the propagation of information. As a result, the overall goal of this research phase is to establish a basis to support subsequent evaluation of informational relationships in communications environments. Results from this research can be used to develop behavioral simulation models to enhance communications. Experimental methods can be used to confirm or disconfirm decision outcomes suggested through simulation. The anticipated contributions from this research are to define opportunities to guide the design of information systems that are robust to variations in information, systems that overcome natural limitations in the ability of people to acquire and distribute information, and, as a result, improve decision making outcomes in organizational settings.

The following sections describe the layout of this paper. Prior research and background information are presented to establish the rationale for the approach used in this study to develop a conceptual framework for extended research. Theoretical perspectives are presented to identify the communications process as a natural phenomenon similar to other phenomena in nature. The final section presents the extended conceptual framework used to describe key features of the communications network and factors that impact the flow of information. Social aspects of the environment are then examined to consider the characteristics and conditions of information and the structures that develop from diverse conditions in social networks.

Prior Research

Information acquisition goals and strategies determine how information is structured and propagates in natural communication processes. As a result, the quality of technologies and artificial systems designed to support the distribution and use of information can exhibit limitations similar to those identified in natural communications. The extant literature in information systems research addresses deficiencies in communications and has considered the development of information infrastructures from a technical perspective. However, concern over the impact of social issues on information structures and communication processes has led to extended research to address the social, economical, institutional, political, and strategic impacts on the structuring of information (Dutton and Dukerich, 1991; Kahin and Abbate, 1995). Empirical research has confirmed a relationship between structures that develop in organizations and their ability to constrain human action. Structuration theories explain the phenomena of human actions as enabled and constrained by structures (Giddens, 1979; Orlikowski, 1992). DeSanctis and Poole (1994) extend this concept to Adaptive Structuration Theory (AST). AST

blends two perspectives of technology and organizational change and provides a more balanced view that accounts for the power of social influences while also considering the potential to influence outcomes using advanced information technologies (DeSanctis and Poole, 1994). While AST focuses on social structures, rules, and resources provided by technologies and institutions as the basis for human activity, there exists the opportunity to extend this research by providing a faith-based perspective that is particularly relevant to understanding the development of information structures and identifying factors that influence information structuration and reveal the actions and intent of human factors in communications networks.

Background Information

The transient nature of information has been widely documented in historical accounts which confirm the need to preserve and maintain the integrity of sacred messages through inscriptions, writings and distribution. The ancients of Egyptian, Babylonian, and Palestinian empires suggest that early manuscripts employed a variety of materials for writing purposes including stone, clay, wood, leather, and papyrus. Although efforts to accumulate and distribute information in written form have changed significantly over time, written documents have in many ways preserved historical records and provided a means to spread messages across the continents.

With the advent of digitized content, the distribution of large volumes of information is achieved with greater ease and speed. The result has been more information in the hands of decision makers, faced with an additional challenge of validating the integrity and quality of messages received through digital content. This change in media has led to the need to consider not only information content but also the composition of information due to diversity in characteristics. The resulting diversity has been linked to several conditions. Diversity in information characteristics has been attributed to factors such as the specificity of information (Choudhury 1997). The concept of information specificity is derived from the concept of asset specificity in Transaction Cost Theory (TCT) (Coase, 1937; Williamson, 1975; Williamson, 1985). Just as asset specificity refers to the extent to which the value of an asset is restricted to specific transactions, information specificity is defined as the extent to which the value of information is restricted to certain uses or acquisition modes by specific individuals or during specific periods of time.

In the context of information, several forms of specificity have been defined. Information that is highly knowledge specific can be acquired and used only by individuals or groups with required specific knowledge. Information that is highly time specific must be acquired immediately or soon after it first originates and decreases in value unless used shortly after it becomes available. An extension of these constructs, transfer specificity, is suggested in the literature which considers the extent to which information must be transferred over rich communication channels (Daft and Lengel, 1984). Media richness theory, first proposed by Daft and Lengel (1984), presents a hierarchy of media which determines the richness of the information transmitted. Information richness is used to explain how individuals and organizations meet the need for certain amounts of information and the need to reduce ambiguity or equivocality (Lee, 1994). However,

contradictions to media richness theory, including empirical evidence, have been presented that would challenge the need to consider transfer specificity as a viable construct (Contractor and Elsenberg, 1990; Fulk et al., 1990; Markus, 1991; Yates and Orlikowski, 1992; Lee, 1994). However, the need to better understand the propagation of information in critical communication processes presents the opportunity to reconsider the viability of transfer specificity. Although choice of media may not determine the richness of information transmitted, the richness of the distribution network may provide a reasonable explanation for this phenomenon. This explanation could be considered valid in that structure only exists in and through the actions of people (Giddens, 1989).

Relative to time, information characteristics are defined in a recursive manner based on factors such as the availability of related information as well as the value ascertained by the user. In turn, the characteristics of information vary in time and space, as information is distributed through communication channels composed of people in global settings, with diverse personalities, aptitudes, cultures, values, and preferences. Socio-technological settings, which include the stock of knowledge possessed by individuals and technology, are constant in the short run, although social networks tend to restructure over shorter periods of time based on factors such as information availability and personal interests. A similar view is acknowledged in prior research by Orlikowski, (2000):

> *Technologies-in-practice can be and are changed as actors experience changes in awareness, knowledge, power, motivations, time circumstances, and the technology. They are changed through the same process that all social structures are changed—through human action.*

Technologies-in-practice are defined where people constitute and reconstitute a structure of technology use through their experiences, knowledge, meanings, habits, power relationships, norms, and the technological artifacts available (Orlikowski, 2000).

Information flows are dynamic elements that are in turn impacted by spatio-temporal conditions and therefore reflect the actions and decisions of people. Information that is limited in acquisition and use at specific times and by people with specific knowledge is characteristic of a dynamic communication environment. In such an environment, distortions in information - breakdowns in the quality and availability of information – occur and are often associated with information characteristics. Information quality can be influenced by characteristics such as source and type. However, because information characteristics change in time and space and is further influenced by the diverse nature of people, distortions occur through the actions of people and therefore result in fragmented information structures. The increased use of digital communications amplifies this condition as a virtually unlimited amount of information derived from multiple sources is made available to naturally-bounded individuals who utilize the same in critical decision making processes.

Theoretical Perspectives

Theories of related phenomena in nature can be used to explain the propagation of communications as a natural phenomenon. Observations posed in the theory of optics (electromagnetic theory as the study of the propagation and evolution of electromagnetic waves) along with Huygen's idea of an ether or "gas" as a transport medium for light both suggest that natural phenomena require a support structure or medium to facilitate propagation. Research on the development of the World Wide Web also provides evidence that phenomena that initially appear to exhibit random behavior actually follow natural patterns of connectivity. Small World theory (Mahowald and Milgram, 1968) has been used to explain this phenomenon and suggests the existence of Strongly Connected Components (SCC) in networks or highly concentrated, "very connected super nodes" that provide connectivity to less well-connected nodes. Such theories have been used to explain the structure of the World Wide Web, not as random, but as a "scale-free" network where parallels are found in disease transmission and computer viruses (Newman, Barabasi, & Watts, 2006). Such structures or scale-free networks are considered highly vulnerable to destruction, i.e., destroy their super nodes and transmission of messages break down rapidly.
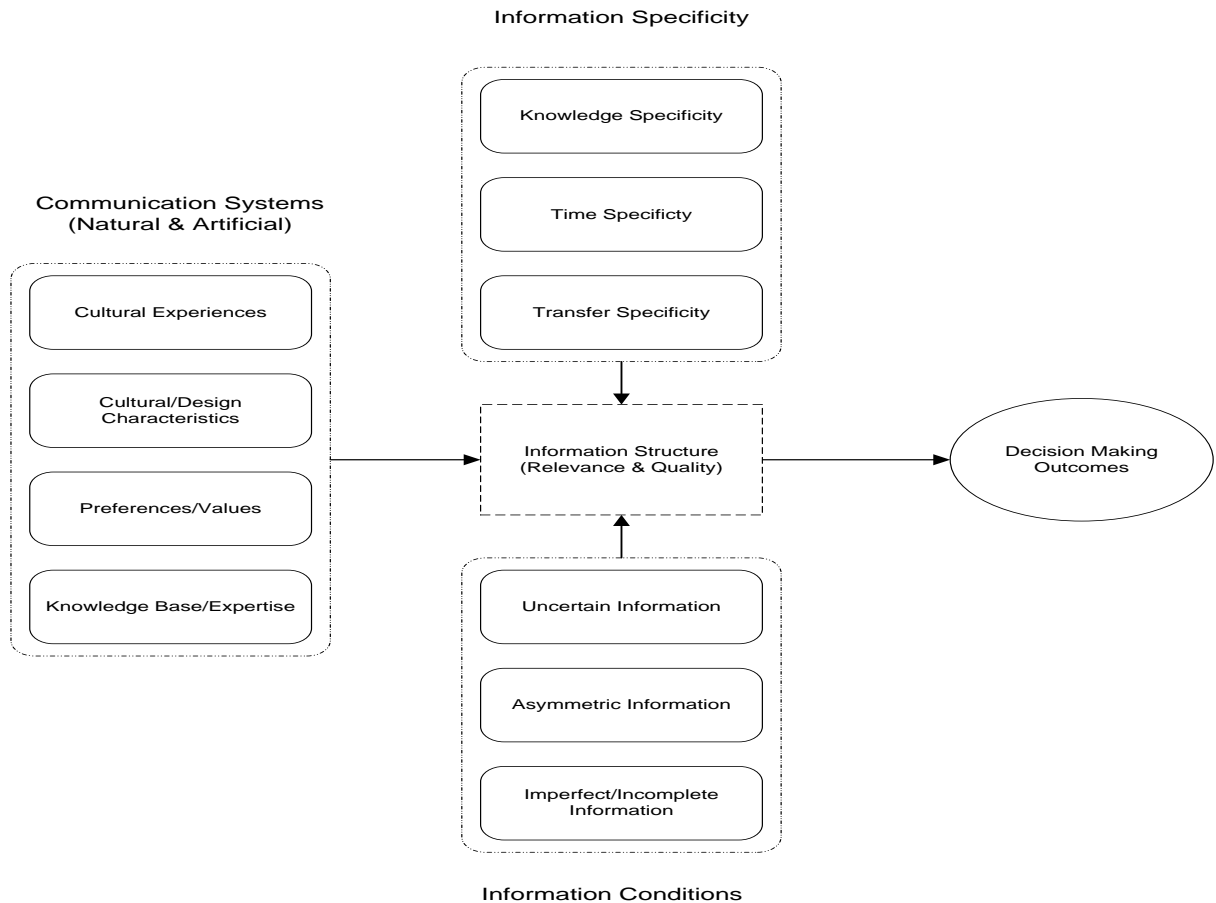
Prior research in thermodynamics has evaluated the degree of order and disorder in complex systems through measures of entropy. In scientific laws, entropy is regarded as a measure of disorder. By observation and as confirmed in prior research, nature tends toward maximum entropy for any isolated system (Nave, 2005; Bailey, 2001). Because nature tends to take things from order to disorder, a study of natural variations in information structures in communications networks could help clarify relationships in communications.

A more concise way to characterize entropy in nature is to define it as a measure of the "multiplicity" associated with the state of objects. If a given state can be accomplished in many more ways, then it is more probable than one which can be accomplished in only a few ways. Multiplicity can be observed under many natural conditions. As in a glass of water, an array of ice chips may look more disordered in comparison to a glass of water which looks more uniform and homogeneous. But the ice chips place limits on the number of ways the molecules can be structured. The water molecules in the glass of water can be arranged in many more ways; therefore, they have greater "multiplicity" and therefore greater entropy (Nave, 2005).

The concept of system multiplicity has been defined as a measure of entropy in research dealing with complex systems (Shannon and Weaver, 1949; Kluge, 2000). In the context of communications as a system of information acquisition and management, natural conditions of multiplicity can be studied to promote the development of communication systems that are robust to changes in information characteristics and conditions.

An Extended Research Model

The theoretical perspectives presented above suggest the following extended research model:

Information Specificity

Knowledge Specificity

Time Specificty

Transfer Specificity

Communication Systems
(Natural & Artificial)

Cultural Experiences

Cultural/Design
Characteristics

Preferences/Values

Knowledge Base/Expertise

Information Structure
(Relevance & Quality)

Decision Making
Outcomes

Uncertain Information

Asymmetric Information

Imperfect/Incomplete
Information

Information Conditions

Figure 2. Extended Conceptual Model of Relationships in the Communications Environment

Each category of the communications environment is discussed in the following sections.

Information Specificity

The impact of the knowledge embedded in individuals and the timeliness of information is apparent in decision making outcomes. Traditional decision making models suggest that problems are attended to in order of importance and expected value (Newell and Simon 1972; Simon 1965). The idea of temporal importance was extended by Saunders and Jones (1990), who suggested that various sources of information and media are more appropriate at different phases of the decision making process. Given the significance of

time in the acquisition, use, and transfer of information, the importance of knowledge and time are considered in the development of information structures.

Because information is a flow, any effort to the acquire information must consider the dynamic effects that are part of the communications process. Likewise, there are constants or static elements in nature that allow the prediction of the course of information flows. As a river, information has a source and destination and random effects such as ebbs and valleys, with various intermediate points of distribution. Therefore, natural phenomena govern the course of both.

The option to consider transfer specificity as a characteristic of information addresses the need to better understand communications networks as influenced by differences in people and the unique characteristics added through diversity in multicultural populations. Just as routers and related network devices are used to direct the path of digital communications, unique specificities in information including those established by diverse populations have historically influenced or redirected the path of information and moderated decision outcomes. Just as computer networks consist of highly or super connected components as well as "superspreaders" of information, socio-technical networks are composed of individuals whose diverse nature influence the propagation of information through communication networks.

Information Conditions

Several information conditions influence the acquisition and propagation of information. Imperfect information can be the cause of a decision maker's failure to recognize the importance or relevance of information. Failure to establish relevance can be due to miscommunications in information through lack of knowledge needed to acquire or use the information. States of imperfect information prevent decision makers from recognizing the critical nature of shared messages. Information that is imperfect can reflect the changing state of information as it degrades over time, is transformed, or changes in severity. Information that is valued differently by decision makers or changes over time can negatively impact decision outcomes and create different outcomes in decision making between individuals and groups.

This condition often leads to instances where information is not shared between individuals. Although the cause can sometimes be directly linked to disintegration between information systems, it has been widely researched and acknowledged that individuals frequently engage in opportunistic behavior by deliberately misrepresenting information or restricting access to information for personal gain (Zmud, 1990; Choudhury, 1997).

Information asymmetries can also occur when information is misrepresented through opportunistic behavior. Information asymmetries can occur in critical government operations through lack of transfer of information through chains of command. Information asymmetries represent an imbalance of information that impedes decision making and increases communication costs when information is not shared.

Communication Systems

One of the primary reasons for considering information as a structure is the commonality between communications networks and mechanisms by which information and diseases spread over structures (Newman, 2003; Nelson et al., 2005). Prior research has investigated the development of information structures or communication networks from the stocks and flows of information (Machlup, 1983). Communication networks consist of nodes and connections between each node, where a node represents the stock of knowledge that resides in individuals or organizations. Flows are the communication channels between these entities. Knowledge is also considered to derive from the accumulation or stock of information possessed by an individual based on cultural or acquired experience or training. In this context, information is the steady, ongoing flow of data to which an individual is exposed (Dretske, 1981).

The knowledge that resides within an individual significantly impacts the ability to successfully acquire and process a variety of information. There is considerable agreement in human capital literature regarding the development of knowledge within the individual, especially in terms of training and education (Seetharaman et al., 2004; Bassi et al., 2000; Grasenick and Low, 2004; Youndt, 2004). Human capital typically refers to an individual's or employee's knowledge, skills, and expertise (Youndt, 2004). However, in the area of communications, organizations can effectively enhance their level of human and social capital by developing a pool of culturally diverse individuals within and between organizations. Individuals who work together can gain complementary knowledge through the acquisition of information from relationships external to the organization (Laszlo, 1996).

Understanding the importance of social and human capital has been coupled with research in the field of network science. Prior research in network science has provided mathematical evidence that there are physical laws that govern the structure, evolution and characteristics of all network types, including biological, electronic, disease and information (Hofacker, 1988). Such evidence is discussed here to help define information networks that exist in communications in terms of the structure (nodes and paths) and the flow (direction) of information between individuals in multicultural populations and finally to decision makers.

When considering the flow of information, prior research in organizational communication has explained a wide variety of organizational phenomena. Smith, Grimm and Gannon (1992) proposed a theory of communication-information that supports prior research which emphasized the centrality of communication in determining both the structure and scope of organizations. Theories of organizational communications have been used to explain a wide variety of organizational issues including decision making (Duncan, 1973; McPhee and Tompkin, 1985; Jablin et al., 1987). Information theory was designed to optimize the transmission of information through communication channels (Shannon, 1949). Communication theory considers

how information flows in communications as well as the processes involved in individual and group decision making. It is widely recognized in the communication literature that information spreads irregularly through a system, arriving at different locations at different times (Guetzkow, 1965). Therefore, prior research in communication-information theory is appropriate to help explain the timing and flow of information.

Adaptive Structuration Theory presents a suitable approach for studying the role of information systems and the opportunities provided by advanced information technologies in communications networks (DeSanctis and Poole, 1994). AST can be used to explain the interaction between human and artificial components in communication networks. The extant literature suggests the development and implementation of information systems that consider the following factors and relationships between them: 1) information dimensions—sources and characteristics (types, quality, specificity in acquisition and use, and spatio-temporal orientations—i.e., time and location orientations to define availability); 2) social contexts (people and their skills, experiences, motivations, decision-making settings and strategies); 3) technology (types, designs, orientations, and implementation) (Kelly, 1978; Huber, 1984; Huber and Daft, 1990).

Conclusion

The focus of this research is to use the knowledge embedded in nature to understand communication networks and to help circumvent the increasing fragmentation of communication and information structures. By considering multicultural factors in communication processes and the natural conditions and boundaries of information acquisition, distribution and use, communication networks can be structured to support critical operations and organizational communication objectives. Because information structures are comprised of human and electronic component systems that are limited in functionality and design by nature, this research makes a significant contribution to both IS research and to advance theories of structuration and adaptive structuration in organizational communications.

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