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The Significance of Information Systems Research on Emerging Technologies: Seven Information Technologies that Promise to Improve Managerial Effectiveness*

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ABSTRACT

Emerging information technologies are those excitingly novel advances that decision makers are just beginning to notice. These emerging products or processes may have been invented some time ago, but are only now beginning to reveal practical applications. This paper examines this collection of seven studies exploring emerging technologies, classifying them so the context of their results can be related to other emerging technologies. Once the research is classified and the contribution and managerial significance of the research is identified, it becomes apparent that certain barriers exist, holding back the technology from wider use and appreciation. Common obstacles include resistance to, or difficulty with, using the technology; uncertainty concerning the value of the technology; and the complexities involved with implementation. This paper concludes with recommendations for future research aimed at breaking down the barriers in order to move from the technological emergence phase to the technological sublime phase in which decision makers and other end users understand the technology, realize and appreciate its value, and put the technology to its best use.

Subject Areas: Decision Support Systems, Distributed Data Processing, End-User Computing, Executive Information Systems (EIS), Group Decision Support Systems (GDSS), Human/Computer Interaction, Hypermedia/Hypertext, Management Information Systems, Social Issues, Team Building, and Technology Management.

INTRODUCTION

Many of us are fascinated when we read about the latest technological innovation. We imagine many of the potential benefits and often want to use the new technology at once. The optimist within us dreams about how the innovation can make

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our lives more meaningful, easier, or just more enjoyable. To be fair, many authors have chronicled the darker side of technology and the evils that it is bound to visit upon unsuspecting people (Dery, 1996; Slouka, 1995; Stoll, 1996). Negroponte (1995) provided a more exhilarating vision of what the potential for "being digital" offers.

Unfortunately, there is often a lag between the invention or discovery of a new technology and the practical application of that technology. For instance, Teflon became an emerging technology when no-stick fry pans were first sold in the United States at Macy's department store in 1960. Teflon was (accidentally) discovered in 1938, but the technology wasn't highly visible until it resonated with the American purchasing public. Of course, today Teflon is used in countless products because it is an excellent electrical insulation material, stable over a wide range of temperatures, and resistant to most corrosive agents. We are so conversant with Teflon's physical properties that when the mass media apply the term "Teflon" in a figurative way, we instantly recognize that even the highly publicized blunders of politicians will not "stick" to them.

For the purpose of discussion, the life cycle of technology in the following five, somewhat overlapping, phases of technological advancement will be described: (1) technological invention or discovery; (2) technological emergence; (3) technological acceptance; (4) technological sublime; and (5) technological surplus. The term "sublime" has the greatest positive connotation, and deservedly so. This is the phase in which a technology is fully understood, appreciated, and put to its best uses.

The intent of this special issue is to explore research being conducted on emerging information technologies, which occur in the second phase of technological advancement. To emerge means "to come forth from obscurity" (*The American Heritage® Dictionary of the English Language*, 1992). All of the technologies described in this issue are known by researchers. Their invention or creation was some time ago. Decision makers and other end users, however, may be unaware of the details, the inherent potential they offer, or how to make use of these technologies. In that sense they are emerging.

Why should researchers study and write about emerging technologies? The basic possibilities include advancing the field in order to (1) improve or promote the technology to gain its wider acceptance and use, (2) distribute the technology to a wider set of end users, and (3) understand how to implement, use, and value the technology. These possibilities correspond to the technological acceptance, technological surplus, and technological sublime phases in the model presented.

The first reason for researching emerging technologies is to improve the technology so it achieves acceptance. An article aligned with this purpose might be more suitable for a scientific or trade publication. The second reason for researching new technology is to understand it better so it can be distributed or disseminated to a growing set of end users. The third reason to study and research technology is to understand how to implement, use, and value the technology. This research benefits the fourth phase, the one referred to as the technological sublime. All of the papers contained in this special issue serve as supports for the building of bridges from technological emergence to the technological sublime.

In the technological emergence phase, managers learn how to employ technology to its fullest, including such functions as using decision support models, computerizing procedures, and facilitating communication. In the process, managers are educated and also train others in the use of IT. Additionally, managers learn about planning for IT and how to avoid unique organizational problems created by newly adopted technology. In an in-depth study of IT managers and technological changes, Benamati, Lederer, and Singh (1997) chronicled common problems faced by IT managers in this phase. Additionally, they identified and classified the coping mechanisms that managers use to address problems created by emerging information technologies, which include "education and training, inaction, internal support, vendor support, new procedures and persuasion" (p. 275).

The remainder of the paper is organized as follows. The seven emerging technology articles are classified as to: whether they examine production-oriented or coordination-oriented technologies; the level of analysis (that is, whether it emphasizes the individual, team, or organization); and the research methodology used. Following this classification, the contributions made by the researchers of each of the seven papers is articulated. Barriers to reaching the phase of the technological sublime are surfaced, and finally, original recommendations for overcoming them are provided.

FIVE PHASES OF TECHNOLOGICAL ADVANCEMENT

As noted in the introduction, the life cycle of technology is described in the following five, somewhat overlapping, phases of technological advancement:

1. technological invention or discovery,
2. technological emergence,
3. technological acceptance,
4. technological sublime (in which its value is fully appreciated), and
5. technological surplus.

The fifth phase could result in a continual use of, and perhaps overindulgence in, the technology (e.g., the wheel and the overabundance of vehicles); additional higher order inventions; or the discontinuance or decrease of the technology (such as the fountain pen) when it is replaced by an improved technology (such as the ballpoint pen). The seven research papers in this special issue all study and report on emerging technologies (phase two).

CLASSIFICATION OF SEVEN EMERGING INFORMATION TECHNOLOGY PAPERS

Even though all seven articles in this special issue focus on the second phase, it is appropriate to examine the differences among them. First, the papers differ in their orientation. Some are production oriented, meaning that the technology enables tasks to be accomplished more efficiently and decisions to be made more effectively. Others are coordination oriented, encouraging communication or cooperation.

Secondly, the studies differ based on their level of analysis, including studies affecting the individual, organization, or teams. Finally, the articles differ because the authors adopt a variety of research methodologies, including field studies, laboratory experiments, and surveys. These three dimensions are further explored below. An elaboration of the classification of the seven emerging technology articles in this issue is presented in Table 1.

Technological Function

The first dimension attempts to classify the papers according to their purpose or function loosely based on definitions by Henderson and Cooprider (1990). Three separate dimensions of support technology functionality are distinguished: production-oriented technology, coordination-oriented technology, and organizational-oriented technology. Note that the group of articles discussed here does not include an organizational-oriented technology. (For further exposition of these three classifications see Lyytinen & Kendall, 1992.)

Production-oriented Technologies

A production-oriented technology implies that the emerging technology directly affects the capacity of an individual, organization, or team to efficiently create models, make more effective decisions, or develop alternatives and solutions. Promise of increased productivity, rationalization, or extending the limit of bounded design rationality motivates the development and use of production-oriented technologies that embrace elicitation, analysis, and transformation tasks. Typical elements of production-oriented information technologies are: GUI interfaces (to improve user interaction with decision models), speech recognition (to make data entry more efficient), CASE tools (to improve system design), and hypertext (to more effectively organize and retrieve information). The use of these production-oriented technologies will result in better service to customers, more effective management of information, and reengineered business processes.

Coordination-oriented Technologies

A coordination-oriented technology means that the technology provides ways to enable, intensify, or expand the interactions of multiple agents (i.e., organizational members) in the execution of a planning, design, decision, or implementation task. Use of coordination-oriented technologies are motivated by users' bounded rationality and accrued higher costs of coordination and communication. Sometimes technologies can be used to help reduce geographical and/or time constraints. Coordination-oriented technologies cover *control technologies*, which are means to enforce rules, policies, or priorities over development activities and resources (Orlikowski, 1991); and *cooperative technologies*, which are ways for improving the sharing and exchange of information that can affect the concept, process, or product of IS development (Chen, Nunamaker, & Weber, 1989). Examples of coordination-oriented technologies are: group support systems (cooperation), Executive Information Systems (control and cooperation), email (communication), and video conferencing (cooperation). The use of these coordination-oriented technologies

Table 1: Classification of seven papers on emerging technologies.

Authors	Emerging Technology	Technological Function	Level of Analysis	Research Methodology
González and Kasper	Animation	Production oriented	Individual	Laboratory experiment
Ramarapu, Frolick, Wilkes, and Wetherbe	Hypertext	Production oriented	Individual	Laboratory experiment
Guimaraes and Igbaria	Client/Server Systems	Production oriented	Individual	Survey
King and Xia	Communication Media	Coordination oriented	Individual	Quasi-experimental study
Williams and Wilson	Group Support System (GSS)	Coordination oriented	Organization	Field study using qualitative methods
Rai and Bajwa	Executive Information System (EIS)	Coordination oriented	Organization	Survey
Warkentin, Sayeed, and Hightower	Web-based Conferencing	Coordination oriented	Team	Field study

will result in better managerial planning, group decision making, and the coordination of distributed business activities.

Organizational-oriented Technologies

Although organizational-oriented technology is not studied in any of the articles included here, it is important for completeness' sake to note that that these technologies form procedures, standards, and practices that determine the broader environment in which production-oriented and coordination-oriented technologies are put into practice. Their use is motivated by the increased rigidity, visibility, and organizational efficiency gained from standardized organizational behavior. Organizational-oriented technologies include support functions that can range from low-level facilities (such as hypertext help systems) to those that provide help and support functions (expert teams, hot-line services). For examples of organizational-oriented technologies, refer to the personal productivity work by Davis and Naumann (1997). Use of organizational-oriented technologies will allow individuals and organizations to accomplish typical office tasks more efficiently and effectively.

Level of Analysis

The second dimension along which we can understand the research presented here is the level of analysis or "the scope of the study" that distinguishes among

individual effects, team level effects, effects on the IS functional level, and the organization itself. Examples for each level include effects on individual skills and knowledge, changes in team behavior and productivity, higher service level, and improved competitiveness of the firm.

The four papers by González and Kasper, Ramarapu et al., Guimaraes and Igbaria, and King and Xia, all examine individual effects. The two studies conducted by Williams and Wilson, and Rai and Bajwa look at organization effects; and finally, the article by Warkentin, Sayeed, and Hightower looks at team level effects.

Research Methodology

The final dimension used to classify the seven articles included here notes the research methodologies used. The research setting can vary between exploratory and confirmatory research. In exploratory studies we are searching for conjectures and hypotheses that could be chosen as targets of testing in later research. In confirmatory research we are searching for evidence that can confirm our hypothesized knowledge claims. In the research methods discussed here, a distinction is made among field studies, laboratory experiments, quasi-experimental studies, and surveys (Wynekoop & Conger, 1990).

There are four different research methodologies used in the seven articles covered here. The papers by González and Kasper, and Ramarapu et al. both use laboratory experiments. King and Xia use a quasi-experimental approach in their paper. The research by Williams and Wilson, and Warkentin, Sayeed, and Hightower uses a field study approach. A survey methodology is employed in the studies completed by Guimaraes and Igbaria, and Rai and Bajwa. Both quantitative and qualitative methods are to be found throughout the seven papers.

CONTRIBUTIONS FROM RESEARCH ON EMERGING PRODUCTION-ORIENTED TECHNOLOGIES

Research that can be classified as possessing a production-oriented technology is considered first. This classification includes three of the seven papers in this special focus issue: the article by González and Kasper on animation for DSS user interfaces; the paper by Ramarapu et al., researching the use of hypertext for learning; and the third article by Guimaraes and Igbaria that examines the production-oriented technology of client/server systems. The research contributions of these three papers are summarized in Table 2.

Taking the group of three production-oriented technology papers as a whole, it is possible to see that the emerging technologies of animation, hypertext, and client/server systems cover a wide range of technologies designed to affect the way in which many users in many different tasks are supported: making decisions through the use of animated interfaces, solving problems with the enabling capacities of hypertext, and planning and implementing client/server systems.

Animation

González and Kasper take an imaginative approach to the emerging technology of animation by explicitly linking animation and its role in DSS user interfaces. This

Table 2: Contributions from research relating to the emerging production-oriented technologies.

Authors	Emerging Technology	Contributions from this Research on Technological Emergence
González and Kasper	Animation	Decision quality of subjects exposed to parallel navigation interactivity was greater than that of those exposed to sequential interactivity; image realism/abstraction and transition effects require further research.
Ramarapu, Frolick, Wilkes, and Wetherbe	Hypertext	When doing perceptual problems, users of the hypertext or nonlinear system were able to make decisions more quickly and accurately; this translated into superior problem solving as well as higher user satisfaction.
Guimaraes and Igbaria	Client/Server	Developers' skills and organizational support were the most important factors impacting the success of implementing the client/server technology according to user perceptions; the skills demonstrated by the CSS developers appeared to have the strongest effect on the satisfaction of end users.

is innovative in at least two important regards: the first is the opening of an entire realm of possibility with the use of animation in DSS interfaces; the other is their systematic examination of the effect of animation on decision quality via the development and testing of an original framework. González and Kasper define animation as it pertains to the use of DSS interfaces as "Images presented dynamically that change, guided by the user, in ways that improve decision quality."

The authors used a laboratory experiment to compare differences in the quality of decisions made by a sample of 89 student subjects who used differing animation designs in DSS interfaces to accomplish two different decision tasks. In this way they empirically tested three hypotheses that arose via their original framework.

González and Kasper are able to contribute some useful results building on their premise that decision quality is affected by the design of animation. The authors examined interactivity (whether it was parallel or sequential) and found that parallel navigation interactivity translates to superior decision quality. They also examined variables of image abstraction; in other words, whether the images presented to decision makers in DSS should be realistic or abstract. With several caveats concerning the type of decision task, they recommend more realistic images for better decision quality. González and Kasper also examined whether transitions among images should be gradual or abrupt, and (although the results differed depending on the task and were not compelling) they recommend using gradual rather than abrupt transitions between animated images if quality of decision is important.

Hypertext

Ramarapu et al. study hypertext and problem solving to empirically assess whether problem solving using "nonlinear links" would have better results than that using conventional or "linear links." Their study makes a contribution by empirically substantiating relationships that only have been part of our intuitions prior to this time.

Ramarapu et al. used 64 graduate business students to study whether problem solving and user satisfaction were better under linear or nonlinear experimental problem-solving treatments. They used both analytical and perceptual tasks. Interestingly, their findings indicate that the hypertext, or nonlinear system, translated into superior problem solving as well as higher user satisfaction than did the experimental treatment with the linear system. Users were able to make decisions more quickly and accurately when doing perceptual problems using the nonlinear system.

When doing analytical-type tasks, users were also able to perform more rapidly using the experimental nonlinear system. Accuracy of problem solving for the analytical task was seemingly not influenced by whether the system was a hypertext or linear one.

The authors move us to further question the importance of the World Wide Web hypertext-based structure for problem solving, and also give rise to questions about the criticality of evaluating the type of decision task (analytical or perceptual, or some combination thereof) to be supported by a linear or hypertext system.

Client/Server Systems

Client/server systems (CSS) were studied by Guimaraes and Igbaria, who develop a model to examine the success of CSS implementation. One important contribution they make is based on their assertion that past models of successful implementation of information systems should be tested using new client/server technology as the focus. The Guimaraes and Igbaria model centers around people in their interactions with client/server systems, and specifically they test the relationships among: management support, end-user characteristics, developer skills, and end-user involvement in the CSS development process with three measures of system success which they call end-user satisfaction, usage of the system, and impact on end-users' jobs.

The methodology used by Guimaraes and Igbaria was to construct a questionnaire incorporating questions about previously validated models of human factors and their relationship to system implementation. The questionnaire was sent to 500 IS seminar participants, with 148 usable questionnaires returned by IS managers and end-user department managers who were involved with a client/server system project that had been operational for at least one year. The authors used structural equation modeling to test the relationships they had hypothesized among the variables.

Guimaraes and Igbaria found that "developers' skills and organizational support" were the most important factors impacting the success of implementing the client/server technology. The skills demonstrated by the CSS developers appeared to have the strongest effect on the satisfaction of end users. The authors correctly

estimate that the significance of their results will grow in importance as more organizations adopt Web-based systems that feature "information-pull applications."

CONTRIBUTIONS FROM RESEARCH ON EMERGING COORDINATION-ORIENTED TECHNOLOGIES

The second group of articles examines technologies that are coordination oriented. The emphasis here is on supporting a multitude of capabilities for use by multiple participants in order that they are strengthened in their interactions. Coordination-oriented technologies span control capabilities that help enforce policies and procedures to which its users are subject, as well as supporting cooperative endeavors. The four articles included in this classification are: the paper by King and Xia, which examines usage of different communication media; the study by Williams and Wilson examining GSS (group support systems); the article by Rai and Bajwa, who study EIS (executive information systems); and the study by Warkentin, Sayeed, and Hightower exploring Web-based conferencing. The research contributions of these four studies are shown in Table 3.

The four coordination-oriented technology papers show us that the communication media choices of email, voice mail, and fax, as well as the group support systems, executive information systems, and Web-based conferencing, are emerging information technologies that feature aspects of cooperation and control for individuals and teams. Taken as a group, the results of these studies also reflect that researching the coordination-oriented technologies and their capabilities is critical to further our understanding of how they are currently functioning in work situations. Additionally, this type of research demonstrates how coordination-oriented technologies can better be designed in the future. Not only can they fully support the functions necessary for individuals and teams to reach their goals, but they can also promote the building of relationships to help achieve those goals. Further, coordination-oriented technologies can facilitate the embedding of organizational responses (often codified in policies, practices, strategies, and tactics) that foster learning, implementation, and use of emerging information technologies far beyond the work life of any one particular employee.

Communication Media

King and Xia tackle the complex issue of how organizations can help their employees realize early benefits from the adoption of new information technologies by examining how learning experiences with nine different communication media (an electronic meeting system [EMS], email, voice mail, fax, telephone, group meetings, face-to-face communication, letters, and handwritten notes) affect perception of media choice appropriateness. They found that in order to receive desired benefits of new information technology, organizations must do more than simply adopt the technology. They must provide organizational opportunities for individuals to learn new communication media.

Additionally, the research contribution of King and Xia is useful to many IS and communication researchers who are currently formulating their research strategies based on popular and prevalent theories of media richness or social presence.

Table 3: Contributions from research relating to the emerging coordination-oriented technologies.

Authors	Emerging Technology	Contributions from this Research on Technological Emergence
King and Xia	Communication Media	Individual differences and individual experience with a communication medium may be better explanations of media choice phenomena than the prevailing theories of rationality and media appropriateness.
Williams and Wilson	Group Support System (GSS)	Respondents perceive that GSS serve as an "equalizing force" on the power and influence exercised by others in the organization. GSS increase users' participation in decision making; seem to improve access to information and people in the company; allow users an increased opportunity to influence the opinions of other people in the organization.
Rai and Bajwa	Executive Information System (EIS)	Organizations adopting EIS were found to be facing greater environmental uncertainty, possessed more heterogeneity, and were more hostile than organizations that did *not* adopt EIS.
Warkentin, Sayeed, and Hightower	Web-based Conferencing	Teams using this Web-based computer-mediated communication system (CMCS) could not outperform face-to-face groups who experienced the same problem-solving task; group cohesion may be difficult to develop in a virtual environment; the usual ways in which groups control members are not available in cyberspace; and losing members might be a common and unfortunate occurrence.

King and Xia found that individual differences and individual experience with a communication medium may be better explanations of media choice phenomena than the prevailing theories of rationality and media appropriateness. As such, the contribution of this paper may be considerable in altering the course of research into media choice.

King and Xia conducted a longitudinal quasi-experimental study using 295 MBA students to answer the question of whether "the individual's perception of media-task appropriateness remains stable over time as experience changes." Media appropriateness was measured by abstract schemes of tasks, and self-report measures were used to capture an individual's experience with a medium. The authors found that learning experience affected an individual's perception of media appropriateness, particularly as it pertains to use of a new medium. They also found that use of an old medium may dwindle as a new medium is used. King and Xia concluded that organizations can effectively mediate the use of communication technology by providing systematic training and experience for individuals when introducing new communication technologies.

Group Support Systems

In their study of Group Support Systems (GSS), Williams and Wilson use in-depth interviews, observation, and documents to examine organizational context issues in light of the perceptions of group support system users. Their work addresses the notable absence of other reported research examining the use of group support systems, power, and influence in organizations. The Williams and Wilson paper begins to address this lack in the literature.

The authors purposively chose 15 users in one organization, who form a cross-section of all GSS users there, all working in a division of a major U.S. software company specializing in the development of business software tools for desktop PCs. Their rich qualitative evidence suggests many avenues for future research that can be investigated with other techniques, including modeling of organizational variables in a quantitative correlation model.

Williams and Wilson confirm the existence of some of the user perceptions that early GSS developers had hoped to evoke in the initial development of group support systems. They found that their respondents perceived that group support systems increase users' participation in decision-making processes in the organization, and seem to improve access to information and people in the company by making them more approachable. GSS users also report that using the group support system allows them an increased opportunity to influence the opinions of other people in the organization. All of these are made possible by the perception that GSS serve as an "equalizing force" on the power and influence exercised by others in the organization.

Executive Information Systems

The research conducted by Rai and Bajwa develops a theoretical model to examine how a particular set of contextual factors impact the adoption and implementation of Executive Information Systems (EIS) in organizations. Their findings confirm much of what has become part of our best practices in systems implementation, and they mirror much of what we already know about how to conduct successful implementations of other information technology. They also provide practical guidelines for organizations attempting to adopt and implement this emerging technology.

Using a survey methodology, Rai and Bajwa collected data from 210 organizations. Overall, they found that EIS are not broadly in place in the organizations they surveyed, and that the levels of implementation fluctuate across different managerial functions. Rai and Bajwa examined the low level of EIS diffusion in the organizations represented. They found that numerous "environmental and organizational complexities" serve to ensure that EIS will be successfully adopted to serve managerial functions such as communication, coordination, control, and planning.

The authors call for a more thorough study of what it means to support executives with information, asserting that focusing on executive information will enable developers to create systems that address urgent needs in an appealing way.

Penetration of the emerging technology of EIS is limited at this time. Only a third of the organizations surveyed had adopted executive information systems,

with communication being the most frequently supported managerial function. Organizations adopting EIS were found to be facing greater environmental uncertainty, possessed more heterogeneity, and were more hostile than organizations that did *not* adopt EIS.

Web-based Conferencing

Warekentin, Sayeed, and Hightower conducted an exploratory study of Web-based conferencing using a customized version of Meeting Web™, which is a software product developed by CitySource, Inc. Teams using this Web-based, computer-mediated communication system (CMCS) could not outperform face-to-face groups who experienced the same problem-solving task.

This result notwithstanding, the authors make an important contribution to our understanding of real versus virtual teams. They wonder whether the advantages of virtual teams (efficiency, time shifting, automatic documentation, support of geographic dispersion, masking of [irrelevant] social cues) may not be outweighed by some serious disadvantages that surfaced throughout the study. Group cohesion may be difficult to develop, and virtual team members may not develop the strong bonds that can actually improve group communication. They also note that the usual ways in which organizations control team members are not available in cyberspace, and that losing members might be a common and unfortunate occurrence.

Warkentin et al. assert that virtual team communication alters the rules under which we normally communicate. Fortunately, teams can be supported by companies in strengthening the relationships among virtual team members. One of the many suggestions coming out of this study is the idea of combining interactive media during different phases of a relationship. For instance, during early formative meetings, people who will be members of virtual teams should be encouraged to meet face-to-face to set up implicit and explicit norms, share expectations, and begin working together to fashion a relationship flexible enough to withstand the vagaries of virtual meetings.

RECOMMENDATIONS FOR OVERCOMING BARRIERS TO PROGRESS

Each emerging information technology appears to encounter a different barrier that must be overcome, and each obstacle carries implications for future research. When all of the barriers are removed, the technology can be said to have advanced to the technological sublime phase. Nye (1996) summarized the impact of achieving this phase succinctly when he stated:

> The sublime underlies this enthusiasm for technology. One of the most powerful of human emotions, when experienced by large groups the sublime can weld society together. In moments of sublimity, human beings temporarily disregard divisions among elements of the community. (p. *xiii*)

The chief barriers encountered along the way of advancing to the phase of the technological sublime are conceived of as: uncertainty concerning the value of the emerging information technology; the resistance or difficulty with use of it;

and the complexities of implementation. As we have witnessed, each of the emerging technologies researched in this issue (animation for DSS user interfaces, hypertext systems for problem solving; client/server systems; communication media and media choices; group support systems as determinants of power and influence; executive information systems; and Web-based conferencing versus problem solving of face-to-face teams) meets certain obstacles in moving from the emergence phase into the technological sublime, and these are depicted spatially in Figure 1. In the next few paragraphs, recommendations for enabling researchers to overcome or remove barriers are provided. These recommendations are summarized in Table 4.

Researchers encountering obstacles to the valuation of animation specifically in DSS user interfaces should move toward measuring decision quality as it is affected by animation. Most organizations are unfamiliar with conceptualizing how animation in an interface might improve decision quality. Much work is needed concerning the value of images in general, let alone animation, and a starting point is provided by the visual books written by Tufte (1983, 1990, 1997). In *The First Six Books of the Elements of Euclid*, Oliver Byrne in 1570 used symbols and color instead of mathematical symbols (letters a, b, and c in this case) to explain the Pythagorean theorem (Tufte, 1990). Since, four centuries later, we are not learning geometry using these graphic symbols, what is the value of these visuals?

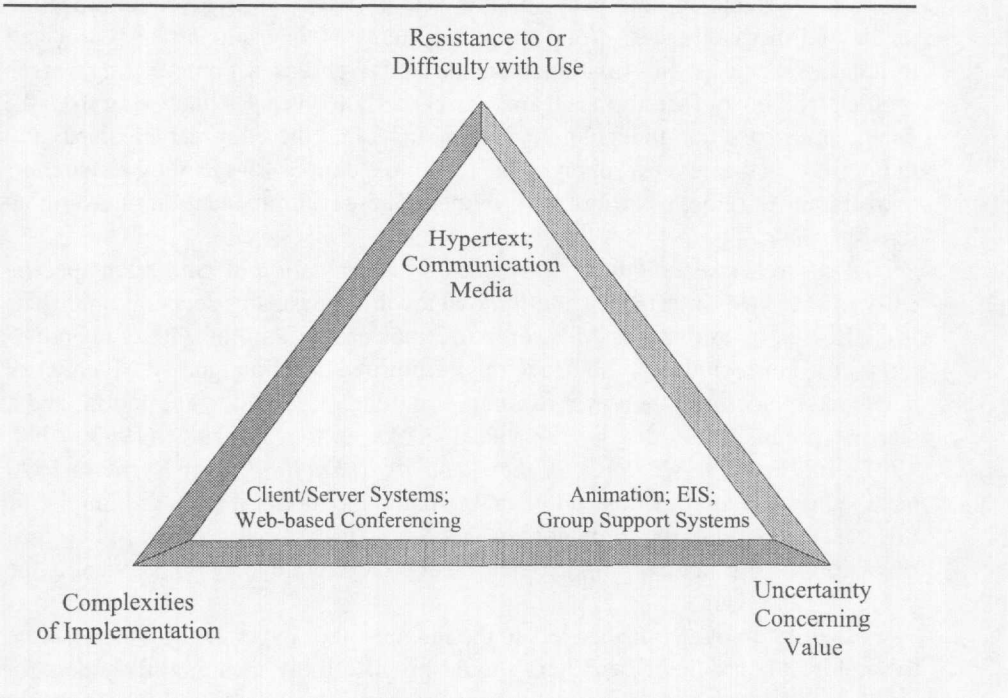
In order to overcome barriers to the movement of hypertext systems into the technological sublime, researchers should propose more meaningful models for problem formulation, taking into account decision phases such as Simon's (1960) intelligence, design, choice, and implementation phases. Additionally, researchers must investigate how nonlinear systems will influence them. Particular attention should be paid to the creation of meaningful contextual searches in hypertext systems that may include graphics, text, video, and audio.

Researchers attempting to overcome nontechnical implementation barriers, as client/server systems move from technology emergence to the technological sublime, should go beyond merely replicating what has been studied before with older system configurations (as wisely noted by Guimaraes & Igbaria). They should consider adding a dimension for time in their systems modeling by matching the stage of organizational development to the type of system required. Client/server systems can also be conceptualized as entities that unfold over time. The work of LeFevre (1987, pp. 41-42), who discussed "inventing in time," is enlightening in this regard.

Recommendations for researchers intent on overcoming the resistance-to-use barriers as they relate to communication media and media choice should concentrate on discovering what organizations are doing to support individual learning, individual experience, and individual choice of media. Future research may need to examine one-to-many forms of communication to ensure message delivery. Romm and Pliskin (1997) have recently demonstrated the strong political potential for the use of email in organizations. The promise email evidences for stimulating collaboration, as well as conflict, are worthy of more research.

The value of GSS still eludes many organizational decision makers. GSS should be broad enough to encompass divergent decision models (Kendall,

Figure 1: Relationship between emerging technologies and the barriers that inhibit transition to the technological sublime phase.



Smithson, & Angell, 1992) as well as more common convergent models. Researchers must create reliable measures of how GSS are affecting power distribution in organizations, if GSS are to move into the technological sublime phase. From a broader perspective, GSS can be widely used to open up societal processes (especially those in newly created democracies) that require cultural embedding and monitoring.

Researchers need to explore the actual and perceived value of executive information and what it means to support executives in their work, since EIS cannot be forced upon an organization. Rapley (1993) humorously labeled this the "plausible impossibility" of supporting top executives. His work can help researchers approach their study of human and social factors of managerial support in an innovative, yet realistic, way. This knowledge should be communicated to organizational members at all levels.

Future work needs to focus on the variables that contribute to making face-to-face groups respond to decisions and problems as a cohesive unit. This research could take into account such variables as the influence of organizational subcultures (Kendall, Buffington, & Kendall, 1987), group metaphors (Kendall & Kendall, 1994), and myths about the creation and maintenance of group cohesion. It is also critical to study how the social interactions of virtual teams can be strengthened to further take advantage of the strengths evident on the Web while muting its disadvantages.

Table 4: Barriers to technology and implications for future research enabling progress towards the technological sublime.

Emerging Technology	Barrier to the Technology	Implications for Future Research Enabling Progress Towards the Technological Sublime
Animation	Uncertainty concerning the technology's value	Researchers should move towards an assessment of decision quality and animation since the value of animation is still questioned.
Hypertext	Resistance to or difficulty with the technology's use	Since hypertext will continue to be rapidly adopted, often replacing linear systems, researchers should examine innovative models for problem formulation and meaningful, contextual searches in the nonlinear decision world.
Client/Server Systems	Complexities of implementation	Researchers should continue to evolve models of CSS implementation and other systems, perhaps adding a dimension for time that matches the stage of organizational development to the type of system required.
Communication Media	Resistance to or difficulty with the technology's use	Since we cannot assume *everyone* will embrace *every* communication technology, researchers need to concentrate on individual differences. Future research may need to examine one-to-many forms of communication to ensure message delivery.
Group Support System (GSS)	Uncertainty concerning the technology's value	Create reliable measures of how GSS is affecting the power in organizations. GSS can be widely used to open up societal processes, especially those in newly created democracies.
Executive Information System (EIS)	Uncertainty concerning the technology's value	Since an EIS cannot be forced upon an organization, researchers need to explore the value and perceived value of EIS, and communicate that to organizational members at all levels.
Web-based Conferencing	Complexities of implementation	Future work needs to focus on the variables that make face-to-face groups a team, including group cohesion due to organizational subcultures, group metaphors, and myths. Then study how a virtual teams approach can be implemented to take advantage of the web and mute the disadvantages.

CONCLUSION

Honestly appraised, our progress through phases of technological advancement is anything but a smooth ride. Moving by fits and starts, greeted with disheartening setbacks and exhilaratingly great leaps, we struggle as information systems

researchers to understand what is happening, how, and why. We ask, "Who will be involved in the complex processes of moving to the next phase of information technology?" all the while fretting over who should be involved in moving toward the technological sublime. We question and query, anxiously wondering what roles we are to play—as researchers, as organizational members, as humans in society—as we witness an explosion of technology undreamed of even in the last generation.

The answer echoes back to us through the research presented here: we are the ones who must understand how to implement new information technology; we must comprehend its uses; we must make the determinations of how best to value it. And although the invention or discovery of new technologies seems at times to be tinged with an aura of inevitability, our reactions and creations as researchers must not be.

Indeed, the authors whose work is represented here were not satisfied to let information technology just happen, *sans* chronicling, *sans* examination. Their contributions have made it possible to carry forward an enlightened dialogue about emerging information technologies. Derry and Williams (1993) in their book, *A Short History of Technology*, were cautiously optimistic about human technological advancement made thus far, stating, "But to the more searching question, whether technological progress has on balance added to the happiness of the individual, we can at best offer no more than an affirmative answer hedged with qualifications, rejecting the temptation to pretend to weigh imponderables" (p. 710).

But even acknowledging this careful assessment, we are now empowered to ask discerning questions, refine our hypotheses, reconstitute our samples, supplement our methods, and examine our results with confidence that the answers we derive will help shape our future in ways that will benefit whole societies, not just individuals. This last point is critical, for as Harrington (1962, Appendix, section 1) observed, "If there is technological advance without social advance, there is, almost automatically, an increase in human misery, in impoverishment." Information systems researchers can be instrumental in preparing the way for a transition to the technological sublime that is mirrored by our corresponding development as a society.

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