THE ROLE OF WORKSTATION-BASED CLIENT/SERVER SYSTEMS IN CHANGING BUSINESS PROCESSES: A MULTIPLE CASE STUDY

DISSERTATION

Presented to the Graduate Council of the

University of North Texas in Partial

Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

By

Nik Rushdi Nik Hassan, B.S., M.B.A.

Denton, Texas

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Although several studies question information technology's contribution to productivity, organizations continue to invest in client/server systems (CSSs) particularly as enablers of business process reengineering (BPR). These efforts may be wasted if they do not improve business processes. This study focused on business processes and investigated the role of workstation-based CSSs in changing business processes. A multiple case study of workstation-based CSS databases in three organizations was performed with the proposition that they moderate the relation between managerial action and changes within business processes. The research framework suggested that changes to business processes are achieved by reducing uncertainty.

In order to measure change in business processes, this study categorized business process change into: (1) compressing sequential tasks across functions, (2) compressing tasks vertically within the managerial hierarchy, (3) eliminating slack resources, (4) reducing the distance between the point of decision and the point of information or eliminating intermediaries, (5) reconfiguring sequential processes to operate in parallel, and (6) linking parallel activities during the process. Data collected from questionnaires, interviews, and observations from three case studies were used to construct network

diagrams, relationship matrices, reachability matrices, and task tables of business processes.

The results of this research partially support the proposition that managerial action affects business process change by reducing uncertainty. This research suggests that changes in the use of workstation-based CSSs are related to changes in business processes. However, because of the small sample size, no finding was made regarding changes in the *strength* of that relationship. Therefore, within its limitations, this research (1) partially supports the proposition that CSSs moderate changes in business processes, (2) found that both favorable and unfavorable changes may result from using CSSs, (3) explains how business process change occurs, and (4) suggests new variables for measuring successful BPR.

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CHAPTER 1

THE OVERVIEW OF THE RESEARCH

Introduction

This study investigates how well U.S. businesses are using client/server technology to change business processes. It explores the relationship between the implementation of client/server technology and the organizational changes that take place as a consequence of that implementation. The research question for this study is, *how* do client/server systems facilitate business process change? The objective of this research is to explain the role of client/server systems within the context of an organization's efforts in business process reengineering (BPR).

Motivated by intense competition and other business pressures, many organizations have redesigned their business processes to achieve higher profitability (Hammer and Champy 1993; Davenport 1993). These redesign efforts often involve large investments in client/server technology that are workstation-based, as opposed to centralized mainframe or minicomputer technology (Salemi 1995; Manganelli and Klein 1994; Baxter and Lisburn 1994; Trimmer 1993; Guengerich 1992). Several research studies have shown that investments in information technology (I/T) have not resulted in any productivity improvements (Musgrave 1986; Kominski 1991; Roach 1991; Loveman 1988). Other authors have tried to explain this "productivity paradox" as a problem of

measurement and improper use of information technology (Curtis 1993; Davenport 1993; Henderson and Venkatraman 1993; Hammer and Champy 1993). Very little research has been performed to show whether investments in any I/T contribute to BPR efforts (Davenport 1993; Henderson and Venkatraman 1993). Although many studies on I/T's impact on organizations have been performed, most studies reporting recent I/T-enabled BPR cases have been predominantly anecdotal. This study is one of the few that explores the relationship between I/T, specifically workstation-based client/server technology, and business process change.

A Definition of Terms

Many organizations have opted to use workstation-based client/server technology as opposed to non-client/server types of I/T, or client/server technology designed for the mainframe and minicomputer platforms (Kamisetty 1993; Sinha 1992; Salemi 1995; Manganelli and Klein 1994; Baxter and Lisburn 1994; Trimmer 1993; Guengerich 1992). Many reasons have been given for this choice. Among the most quoted reasons are (1) cost of hardware, software, and support staff (Berson 1993; Renaud 1993; Trimmer 1992; Kavanaugh 1995; Guengerich 1992; Johnson 1992 cf. Berg 1992; Kennedy and Gurbaxani 1994), (2) increased system performance (Berson 1993; Renaud 1993), (3) system extendibility (LeLann 1981; Dewire 1993), (4) increased system availability (Cashin 1993; LeLann 1981), (5) better resource sharing (Dewire 1993; Sinha 1992), (6) local autonomy and employee empowerment (Kappelman and Guynes 1995; Renaud 1993), (7) processing load balancing and optimal network utilization (Sinha 1992; Dewire 1993), (8) enhanced

access to data, services, and applications (Renaud 1993; Cashin 1993; Smith 1992), (9) application-independent and easy-to-use graphical user interface (Berson 1993; Dewire 1993), and (10) improved system interoperability (Berson 1993; Renaud 1993; Dewire 1993). The movement toward workstation-based systems instead of mainframe-based (and minicomputer-based) systems is often referred in the trade literature as "downsizing" or "rightsizing" (Sinha 1992; Trimmer 1992; Kavanaugh 1995; Guengerich 1992). The organizational implications of this workstation-based I/T is the focus of this research. The results of this research may be generalized to other forms of client/server technology.

Workstation-Based Client/Server Information Technology

I/T has always been considered critical for the effective management of an organization (Ackoff 1967; Dearden 1972). In the beginning, I/T was employed in a support role for various organizational activities (Gorry and Scott Morton 1971). More recently, I/T has gained increased visibility as a competitive weapon, and as a critical component in corporate strategy (Parsons 1983; Porter 1980; Porter and Millar 1985; McFarlan 1984). As a result of global economic and competitive pressures, organizations are looking at further expanding the role of I/T in order to overcome these pressures (Tapscott and Caston 1993). One of these roles is in improving or changing business processes to increase profitability (Davenport 1993; Hammer and Champy 1993). The type of technology that is employed to achieve this change is client/server systems.

Considerable confusion exists among authors writing about client/server systems and among vendors of client/server systems (Berson 1993; Cerrutti and Pierson 1993;

Renaud 1993; Kamisetty 1992). Client/servers have been claimed to be merely traditional time-sharing systems scaled-down to the more contemporary "cooperative processing systems" (Kamisetty 1992). Perhaps, the term "client/server" is still in the process of being defined. For the purpose of this research, a client/server system is defined as a distributed system that physically splits the processing performed by the client computer from that performed by the server computer, while presenting a single logical picture to the user (Kappelman and Guynes 1995).

Client/server systems need not be workstation-based, since the emphasis of client/server computing is not hardware. However, the focus of this research is on workstation-based client/server systems, as opposed to client/servers systems that operate on mainframe and minicomputer hardware platforms. The reason for this focus is the increase in use of such workstation-based applications (Sinha 1992; Trimmer 1992; Kavanaugh 1995; Guengerich 1992), especially in BPR efforts (Davenport 1993; Hammer and Champy 1993; Manganelli and Klein 1994; Baxter and Lisburn 1994; Trimmer 1993; Guengerich 1992).

Business Process Redesign or Business Process Reengineering

The concepts of business process redesign and the impact of I/T on business processes gained currency as a result of work published by Hammer (1990) and Davenport (1990). This study refers to business process redesign and business process reengineering (BPR) as one and the same. Numerous anecdotal reports claim that BPR has made companies more profitable (Hammer and Champy 1993; Davenport 1993; Day

1992; King 1991; Palmer and Burns 1992). Although the benefits of BPR have perhaps reached the level of conventional wisdom in industry, only one research study has empirically shown that BPR results in improved profitability (Venkatraman and Akbar 1991).

This research equates BPR to business process change. Business process change is defined as a modification in the collection of activities performed by the members of an organization, or by subunits of an organization. These activities must be designed to produce a specific output that is of value to an external or internal customer. An external customer is defined as a recipient of the product or service who resides outside the boundaries of the organization producing that product or service (e.g., a buyer). An internal customer is a recipient of the product or service who resides within the boundaries of the organization (e.g., management staff receiving reports from a reporting process). Many authors proposed that BPR should be undertaken using client/server technology (Davenport 1993; Hammer and Champy 1993; Manganelli and Klein 1994; Baxter and Lisburn 1994). It is the purpose of this study to investigate the role that client/server systems have, if any, in facilitating BPR.

The Research Problem

Several studies dismissed the contribution of I/T to organizational productivity, calling the problem the "I/T productivity paradox" (Brynjolfsson 1993; Musgrave 1986; Kominski 1991; Roach 1991; Loveman 1988). Other researchers argue that, in addition to suffering from a problem of measurement, I/T has not resulted in comparable

improvements in productivity, because U.S. businesses fail to take full advantage of I/T's capacity to change the way work is performed. This study will investigate how well U.S. businesses are taking advantage of I/T's capabilities to change business processes.

The focus of this research is the implementation of BPR through the use of I/T. Both Davenport (1993) and Hammer and Champy (1993) emphasize that I/T is an indispensable component for BPR. Hammer and Champy go so far as to stress that "a company that cannot change the way it thinks about I/T cannot reengineer" (Hammer and Champy 1993, 82). I/T, they note, should be able to "disrupt" the rules that limit how businesses conduct their work, and therefore achieve competitive advantage. Examples of how I/T enables such a change are given in appendix A. Davenport (1993) identifies I/T as one of three major "enablers" for process innovation. The other two enablers are organizational enablers and human resource enablers. Davenport (1993) lists several opportunities for I/T to support process innovation. This list is given in appendix B. This dissertation questions Hammer and Champy's (1993) and Davenport's (1993) assertions, and investigates how I/T facilitates BPR.

Several researchers, both in the economic and I/S fields, have repudiated the contribution of I/T to organizational productivity. Between 1978 and 1985 in the U.S., I/T has more than tripled as a share of total equipment stock, growing from 1.8 percent to 7.8 percent (Musgrave 1986). In 1988, I/T accounted for 42 percent of total business equipment expenditure in the U.S. (Kominski 1991). However, macroeconomic data have shown that I/T has not contributed to raising productivity. Using government productivity

data, Steven Roach (1991) showed that where I/T and overall capital spending were highest (notably in the service sector), the productivity increases were the lowest (0.8% since 1982). Roach (1991) states that downsizing in services alludes to I/T's failure to generate productivity increases. In another study, Loveman (1988) found no significant positive productivity impact from I/T investments in manufacturing, in which productivity gains have been generally higher than in the service sector.

Davenport (1990,1993), Henderson and Venkatraman (1993), Shnitt (1993), Hammer (1990), Hammer and Champy (1993), Venkatraman and Zaheer (1990), Tapscott and Caston (1993), McKersie and Walton (1991), and Scott Morton (1991) argue that I/T has not resulted in comparable improvements in productivity because U.S. businesses fail to take full advantage of I/T's capacity to change the way work in organizations is performed. Davenport (1993) refers to changing the performance of work as "process innovation." Other terms referring to the same concept include "business process reengineering" (Hammer 1993) and "strategic alignment" (Henderson and Venkatraman 1993). Davenport (1993) purports that favorable economic outcome can only be achieved when I/T initiatives are taken to change business processes. These innovative business processes, together with equally innovative efforts in managing human resources, will generate the required increases in productivity (Figure 1).

Hammer and Champy, in discussing process reengineering, emphasize that changing how work is done is "the single best hope for restoring the competitive vigor of

American businesses" (Hammer and Champy 1993, 5). Another reason that macro-economic data do not reflect I/T's contribution has to do with the nature of the outputs from I/T. Outputs from I/T are not measured in manufactured products or in a building's construction.

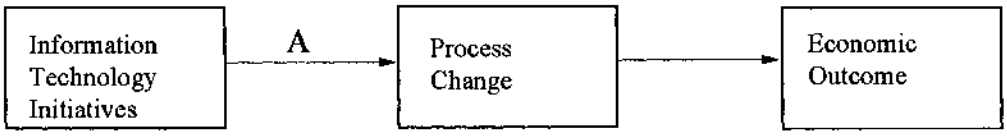

Fig. 1. The I/T -- process -- productivity relationship. Adapted from Davenport (1993)

This lack of measurement is exacerbated in the service sector. Often, outputs from I/T are immediately consumed when produced. The value of the output is often measured in terms of intangibles to the purchaser (Curtis 1993; Scott Morton 1991). Also, the relationship between I/T and the components of an organization can be very complex (Delone and McLean 1992; Galbraith 1977). Furthermore, there is a lack of field study research to measure the influence of I/T on organizational performance (Delone and McLean 1992). One contribution of this study is to explain this complex relationship and show I/T's contribution to the organization. In support of I/T, Curtis (1993) listed tangible impacts of I/T on business structures. These impacts included the creation of new industry structures (e.g., telecommunications and the mail order industry), new revenue streams (e.g., American Airlines SABRE and automated teller machines), new cost elements (e.g., training and maintenance), the birth of the "global village," and increased individualized services (e.g., brokers).

Purpose of the Research

The purpose of this research is to describe the role of client/server systems in changing business processes. This study does *not* attempt to show that BPR results in favorable economic outcomes; rather, it attempts to show how client/server systems enable change to occur in business processes. It concentrates on the relationship between the implementation of client/server systems and the change in business processes (arrow A in figure 1). It does not argue for BPR or process innovation. Extensive discussion of the definitions, principles, and implications of BPR can be found in Davenport (1993), Hammer and Champy (1993), Zairi and Sinclair (1995), Grey and Mitev (1995), Hall, Rosenthal, and Wade (1993), and Alavi and Yoo (1995).

Significance and Contributions of this Research

This study is significant because it addresses the complex and practical problem of I/T investment and its effect on the organization (DeLone and McLean 1992). The results from this research will be of great interest to top management and I/S professionals who are implementing or planning to implement client/server systems, as well as other executives involved in BPR. This research will contribute to I/T and organizational change theory because it: (1) clarifies the complex relationship between I/T and organizations, (2) empirically shows the relationship between implementation of I/T and BPR, and (3) adds to the existing set of methodologies in studying I/T and organizational change. The results from this research will contribute to practice because they (1) help

clarify benefits and pitfalls of implementing client/server systems, (2) help practitioners better plan for client/server system implementation by clarifying opportunities and characteristics of I/T that facilitate business process change, and (3) help practitioners better manage I/T-enabled organizational change. Also, very little empirical research has been performed on the subject of BPR and I/T.

This research is timely because it addresses the issue of successful BPR, an effort currently undertaken by numerous organizations in order to improve competitiveness and profitability. It is also timely because it addresses the implementation of workstation-based client/server systems, a fairly recent innovation in I/T that is widely employed in BPR efforts (Davenport 1993; Hammer 1993; Kamisetty 1992; Manganelli and Klein 1994; Baxter and Lisburn 1994).

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CHAPTER 2

SIGNIFICANT PRIOR RESEARCH

First, this chapter reviews research on the relationship between I/T and organizational change. Second, this chapter reviews research on business process reengineering (BPR). Theoretical frameworks related to the focus of this research are introduced, and the chosen theoretical framework of this study, the information processing paradigm, is discussed in detail. This chapter then relates the previous research discussed with the information processing paradigm and BPR.

Previous Related Research on I/T and Organizations

This section describes the relationship of the research problem with previous research. The research problem is defined as the role of workstation-based client/server systems in changing business processes in organizations. Only a few recent studies exactly fit the research problem. However, the study of the impact of I/T on organizations has a long history.

Culnan (1986) traces the origins of this field of research back to a seminal article by Leavitt and Whisler (1958) that speculated on the role of I/T and its implications for organizational design in the 1980s. In a later publication based on a study of 23

insurance companies, Whisler (1970) found that the rerouting of information created new dependencies between parts of the organization and led to increased centralization of power and decision making. Whisler (1970) predicted that computers would result in the integration of subtasks, the displacement of middle management, and a general simplification of organizational structure.

Delone and McLean (1992) offer a comprehensive taxonomy of information systems (I/S) measures that is used as a basis for this study's research framework. Delone and McLean (1992) categorized 100 empirical studies according to six categories of I/S success measures: (1) system quality, (2) information quality, (3) I/S use, (4) user satisfaction, (5) individual impact, and (6) organizational impact. This research falls within the sixth category, which is concerned with organizational impacts of information systems. DeLone and McLean (1992) note that there is not enough field study research to measure the influence of the I/S efforts on organizational performance. This study contributes to this area of I/S research by proposing a new set of measures for I/S success based on changes in business processes.

The set of studies included within each category by DeLone and McLean (1992) was meant to be representative rather than exhaustive. This chapter reviews several of the studies referenced by DeLone and McLean (1992), as well as studies that relate I/T with BPR and changes in business processes. DeLone and McLean (1992) state that the reason for so many conflicting reports on the effects of I/S is that there are many candidate measures for I/S. The chosen measure depends on the objective of the study, the organizational context, the aspect of I/S being addressed by the study, the independent

variables under investigation, the research method, and the level of analysis (DeLone and McLean 1992). Other authors (Markus and Robey 1988; Attewell and Rule 1984) have also offered their explanations for the apparent conflicts regarding the effects of I/S on organizations.

Conflicting Results from I/T-Organizational Relationships

Attewell and Rule (1984) have an extensive review of findings on the relationship of computer information systems (CIS) and organizations. They examined work on the effects of computing on the numbers and quality of jobs, on management decision making, and on organizational dealings with clients and customers. They conclude that findings from these studies are so varied and conflicting because researchers assume that certain elements *must* describe the social impacts of computing in organizations. They suggest that both positive and negative results can occur even with seemingly identical organizations simply because of contextual changes, and they conclude that no simple relationship exists.

Markus and Robey (1988) discuss the importance of good theory to guide research that, when applied, will result in desirable consequences for users, organizations, and other stakeholders. Specifically, they address the structure of theories concerning causal agency, logical structure, and level of analysis. With regard to causal theory, they note that researchers tend to approach the relationship of I/T and organizations from either a technological imperative direction, an organizational imperative direction, or from an emergent perspective. The technological imperative approach focuses on finding

"impacts" of technology on organizations. It views technology as an exogenous force determining organizational behavior. The organizational imperative focuses on the opposite direction of impact, and assumes that technology is the dependent variable. The emergent perspective's view is that complex social interactions create unpredictable uses and consequences of I/T. The essence of this approach includes the role of the computing infrastructure, the interaction of conflicting goals and preferences, and the result of nonrational choice processes. Because of their inherent complexity, emergent models are difficult to construct. The implication of causal theory is the prescription of improved design, resource allocation, and better implementation strategies. Markus and Robey (1988) review studies that correspond to all three causal theory approaches.

The second dimension of theoretical structure discussed by Markus and Robey (1988) is the logical formulation of the theoretical argument. Variance theories and process theories make up the dichotomy in logical formulation. Variance theories are concerned with predicting levels of outcome from levels of the predictor variables. Variance theory posits that the cause is a necessary and sufficient condition for the outcome, and suggest an invariant relationship between the two. Process theories are concerned with how outcomes develop over time, and that necessary conditions alone cannot produce the outcome, but depend on the knowledge of processes. Process theories assert that the outcome can only happen under certain conditions, but may also fail to happen. Although process theories may be more useful in explicating complex phenomena, variance theories should not be completely discounted.

Level of analysis is the third dimension of structure. Markus and Robey (1988) note that when researchers concentrate on the goal of organizations, they neglect to consider the level of analysis -- whether it is at the individual, organizational, or societal level. Different levels of analysis require different causal structures and inferences, although it is arguable that certain types of technology do not submit themselves to any level of analysis. Markus and Robey (1988) stress that researchers should make clear their level of analysis when studying the relationship between I/T and organizations. Markus and Robey's (1988) recommendations have been included in the design of this study's research framework.

After discussing possible reasons for conflicting results in organizational impacts of I/T, the following sections review previous research on organizational impacts of I/T. This review further categorizes the research on organizational impacts of I/T into seven categories. I/T affects: (1) organizational effectiveness, (2) financial and profitability measures, (3) cost/benefit analyses, (4) organizational productivity, (5) organizational structure, (6) organizational strategy, and (7) organizational business processes. This sub-taxonomy serves to further define the taxonomy offered by DeLone and McLean (1992).

Information Technology and Organizational Effectiveness

I/T effectiveness has been a constant preoccupation of researchers for years, and has only recently dropped from the top ten most important issues according to a delphi survey of I/S executives (Niederman, et al. 1991). Hamilton and Chervany (1981a, 1981b) addressed I/S effectiveness from a goal-centered and system-resource view, and

developed a hierarchical framework of system objectives in terms of efficiency and effectiveness. They stress the importance of defining objectives and measures of accomplishments. They suggest the use of service level monitoring, user attitude surveys, post installation reviews, and cost-benefit analyses as measures of system effectiveness. As explained by DeLone and McLean (1992), organizational effectiveness can be viewed as the direct consequence of individual effectiveness and performance.

Information Technology, Organizational Finance, and Profitability

Many of the earlier I/S studies focused on the impact of I/T on the organization's bottom line. Garrity (1963) and the McKinsey study (1968) used return on investment as their measure of I/S success. Chervany, Dickson, and Kozar (1972) chose cost reduction as their dependent variable. Lucas (1975) used total dollar bookings as his measure of organizational performance. Rivard and Huff (1984) surveyed several large companies and asked executives to assess the cost reductions and profits realized from specific user-developed programs. Chismar and Kriebel (1985) measured the relationship between sales, return on investment, and I/S inputs. Ein-Dor, Segev, and Steinfeld (1981) measured the contribution to profit by asking users of a PERT system what savings were realized and what costs were incurred from use of PERT. Perhaps due to the complexity of the relationship between I/T and the profitability of the organization, there is a dearth of studies in this area.

Information Technology and Cost/Benefit Analyses

Cost/benefit analyses include not only monetary value and costs of using I/T but also "intangible benefits" (Hamilton and Chervany 1981a, 1981b). McFadden (1977) developed a detailed computer cost/benefit analysis using a mail order business as an example. Montgomery and Benbasat (1983) presented a cost/benefit analysis of computer-based messaging systems. Money, Tromp, and Wagner (1988) proposed a methodology for quantifying intangible benefits in cost/benefit analyses of a decision support system. Goodhue, Wybo, and Kirsch (1992) investigated the costs and benefits of data integration. Using several case studies and the information processing model as a basis, they showed that company-wide integration may not be the most cost-effective choice for an organization.

Information Technology and Organizational Productivity

I/T productivity has been the preoccupation of many researchers ever since computers began to be used in businesses (Whisler 1957). A considerable amount of research has been undertaken to explain the contribution or lack of contribution of I/T to organizational productivity. Brynjolfsson (1993) discussed what is known and not known about the relationship between I/T and organizational productivity, and explained that the shortfall of I/T productivity is due to both measurement problems and mismanagement by developers and users of I/T. Kraut, Dumais, and Koch (1989) examined the impact of a computerized record system on the productivity and quality of work-life of customer

representatives in a large utility company. Hiltz (1988) studied productivity and social impacts of computing and concluded that any productivity enhancement will be a function of a complex interaction of social and technical systems.

Information Technology and Organizational Structure

Robey (1981) studied eight organizations spanning five countries. He found that computer information systems (CIS) were not independent variables in the change of organizations, but were moderating variables. He discovered that often delegation of more routine decisions to computing functions were mistaken for decentralization, when in fact, power and control may be more concentrated. Therefore, vertical structure was not changed by CIS, but only reinforced by standardization of information, better recordkeeping, and faster processing. Robey found no evidence of CIS achieving participative management. With regard to horizontal structure, he found that CIS formalized lateral relations, reduced informal contact, and worked across existing lines of authority to introduce a more flexible set of reporting relationships. Robey concluded that any organization -- hierarchical, matrix, or dual authority -- seems to be equally receptive to CIS.

Olson (1982) and Olson and Lucas (1982) both discussed the effects of new technology, especially office automation, on the organization. Both articles predicted that organizations would no longer be limited by physical and temporal constraints. Instead they would experience changes in nature and organization of work, interpersonal relations,

organizational structure and processes, skill requirements, amount and nature of organizational communications, management processes, and employee attitudes.

Foster and Flynn (1984) studied the effects of I/T in a General Motors company and discovered three major categories of changes. First, changes in definitions of organizational communications resulted in a wider network of lateral interactions that were more task-oriented, and therefore more useful to the organization. They found that this change increased the number of personal contacts, as electronic media were less threatening than face-to-face meetings. Second, they found changes in the uses and purpose of hierarchies. Instead of the traditional hierarchical focus of power, people who demonstrated competence become more visible. The technology also caused changes in organizational protocol as communications became more spontaneous and task-directed without violating chain of command. Third, they found changes in task performance and task structure. Critical knowledge workers were able to spend more time with work suited for their qualifications, there was more appreciation and understanding of the purpose of the tasks, and tasks became more fluid and more dynamic.

George and King (1991) wrote a thorough review surrounding the debate on whether computerization is related to centralization or decentralization of decision authority structure. They argued that most of the studies on I/T and organizational structure fail to incorporate the role and influence of managerial action. George and King chose not to argue whether or not (1) I/T causes centralization or decentralization, (2) the organization structure is reflected in computerization, or (3) computerization and

organizational structure are unrelated. Instead they concluded that a variety of factors operate simultaneously to shape both what is possible and what is desirable regarding both decision authority structures and use of computing technology. This view of the relationship between I/T and the organization is in agreement with earlier views given by Robey (1982) and Markus and Robey (1988).

Information Technology and Organizational Strategy

This past decade, an increasing number of studies have concentrated on I/T's effect on the strategic decisions that organizations undertake. The most frequently quoted set of studies concerns the impact of I/T on the competitive advantage of a corporation. Porter (1980) developed a competitive strategy framework that has been adopted by other authors as a basis for I/T and corporate strategy choices (McFarlan 1984; Parsons 1983). The value chain and other conceptual frameworks have been proposed as bases for organizing the complex variables surrounding potential implications for I/T and competitive strategy (Cash and Konsynski 1985; Johnston and Lawrence 1988; Porter and Millar 1985; Rockart and Scott Morton 1984).

Although these competitive strategy frameworks provide valuable insight into the variables surrounding corporate strategy and I/T choices, they are less helpful for rigorous research. There is a need for a more complete framework for research into corporate strategy and I/T choices.

Venkatraman (1991), and Henderson and Venkatraman (1993) discuss a strategic alignment model that was used by Kambil (1993) and Loh (1993) in their respective dissertations. Henderson and Venkatraman's (1993) concept of strategic alignment is based on two building blocks: strategic fit and functional integration (see figure 2).

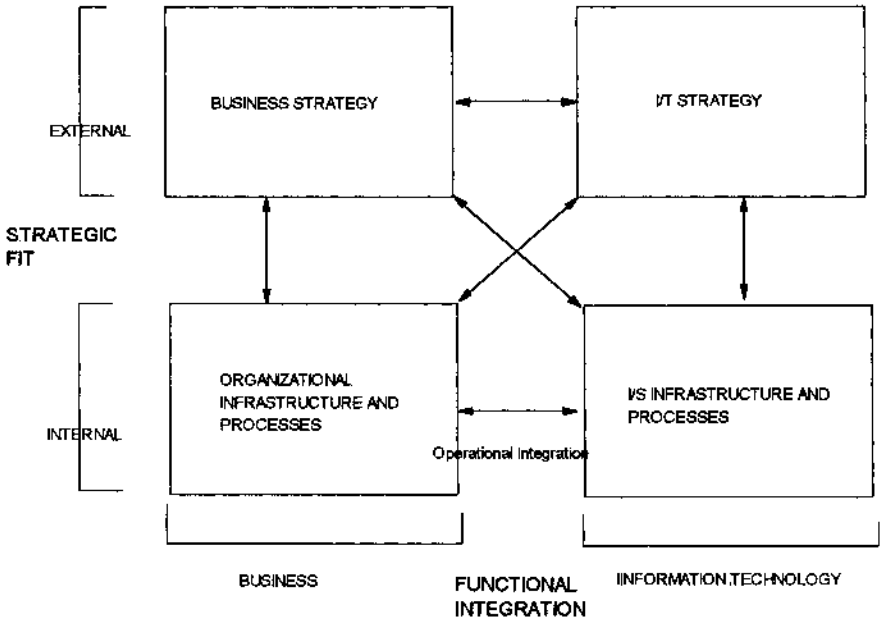

Fig. 2. Strategic alignment model (SAM). Adapted from Henderson and Venkatraman (1993)

The external domain is the business arena in which the firm competes. The internal domain is concerned with choices made toward the administrative structure (functional, divisional, or matrix), and the rationale for the design and redesign of critical business processes, as well as the management of human resource skills. The model argues that the

fit between the internal arrangement of I/T and the external domain of I/T is as important as the fit between the internal and the external business domains.

Venkatraman (1991) emphasizes that the major management challenge is to develop the dynamic alignment between business strategy and I/T strategy. Henderson and Venkatraman (1993) stress that the inability to realize the value from I/T investments is due, in part, to the lack of alignment between the business and I/T strategies of organizations.

The alignment should begin, as suggested by Davenport (1993), from top management down to the rest of the organization (top-down). Henderson and Venkatraman (1993), and MacDonald (1991), describe this approach as making business strategy the driving force. Top management, therefore, play the role of strategy formulator, insisting on redesigning business processes and supplying the necessary political and organizational power and resources. The I/S manager becomes the strategy implementor, who designs and implements the chosen business strategy. In the context of the SAM, the area of this research is represented by operational integration as shown in figure 2.

Information Technology and Organizational Business Processes

Kambil (1993) and Zaheer (1992) performed two recent studies that directly address I/T and its effects on business processes. Kambil (1993) studied the links between electronic integration and patterns of transformation in interorganizational arrangements, using a framework integrated from both Galbraith's (1977) information processing model

and the model developed by Henderson and Venkatraman (1993). Kambil (1993) showed how electronic integration altered the governance of I/T-mediated exchange relations (interorganizational business relationships). He developed in this study a preliminary theory of how electronic integration affected structures, competition, and processes in business networks.

Zaheer (1992) performed a quasi-experiment using companies in the insurance industry to investigate the impact of dedicated electronic integration between an insurance carrier and independent agents with whom it interfaces. Using efficiency (in terms of number of new business policies) and effectiveness (in terms of total written premiums and total commissions) as surrogates for strategic advantage, they hypothesized that electronic integration would have an effect on the increase in performance of the interfaced agents as compared with the non-interfaced agents. Zaheer (1992) showed that business process changes did take place as a result of interfacing. Results show that (1) the interfaced group had consistently better performance levels before integration than the non-interfaced group, and (2) the interfaced group continued to report consistently better performance after the integration.

Previous Research on Business Process Reengineering

As noted in chapter 1, there are very few empirical studies on BPR and business process changes. Hammer and Champy define a business process as "a collection of activities that takes one or more kinds of input and creates an output that is of value to the

customer" (Hammer and Champy 1993, 35). "Business Process Reengineering (BPR)" is defined by Hammer and Champy as:

> The fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service, and speed (Hammer and Champy 1993, 32).

Davenport defines a business process as a "structured, measured set of activities designed to produce a specified output for a particular customer or market" (Davenport 1993, 5). Davenport (1993) uses the term "process innovation" to refer to BPR. Process innovation is defined by Davenport (1993) as combining the adoption of a process view of the business with the application of innovation to key processes. Davenport (1993) stresses that "innovation" is not merely improvement; rather, it means performing a work activity in a radically new way. Innovation involves major changes in organizational structure, power, and controls.

Zairi and Sinclair (1995) identified a set of tools and techniques for BPR. Using a survey, they investigated how these tools and techniques were used in BPR within different industries in the UK. The objective of the survey was to ascertain the level of integration between BPR and total quality management (TQM) within the organizations sampled. They found that on a project basis, BPR appeared to be less successful at organizations implementing TQM. However, when performance measures were

considered, organizations implementing TQM appeared to have gained greater improvements than organizations that did not implement TQM.

Several "how-to reengineer" articles and texts have been written as a result of Davenport's and Hammer's writings. Shnitt (1993) proposes the idea of "strategic reengineering," where every business process should serve the strategy of the organization to compete in the marketplace. Benjamin and Levinson (1993) propose an eight-step framework for performing I/T-enabled change. Obolensky and Page (1994), Manganelli and Klein (1994), and Baxter and Lisburn (1994) offer step-by-step guides for executives and practitioners interested in BPR. Linden (1994) offers a BPR handbook for the public sector and nonprofit organizations. He introduces the concept of the "seamless organization," an organization that emphasizes outcomes rather than bureaucracy. This seamless government centers on BPR principles such as organizing around outcomes, not functions; substituting parallel for sequential processes; bringing downstream information upstream; capturing information at the source; providing a single point of contact for customers and suppliers whenever possible; ensuring a continuous flow of the main sequence; and reengineering before automating.

BPR has its share of critics. It is estimated that between 50 and 70 percent of reengineering efforts fail to achieve the goals set for them (Stewart 1993). Hall, Rosenthal and Wade (1993) studied over 100 companies that undertook BPR, and found how difficult it was to plan and implement. In several cases where process costs and process times were reduced, business unit costs and profits declined (Hall et al. 1993). Hall et al.

attribute this failure to the lack of depth and breadth of the BPR effort. Grey and Mitev (1995) question the assumptions underlying BPR, address its social implications, and attempt to explain why BPR efforts are failing.

Principles of Business Process Reengineering (BPR)

By synthesizing the concepts of BPR discussed by Davenport (1993), Hammer (1990), Hammer and Champy (1993), and Venkatraman (1991), this study proposes six "principles" of successful BPR. These six principles represent the six underlying themes of BPR. If one or more of these principles are achieved in an organization, this study assumes that business process change has occurred.

First BPR Principle: Compressing Sequential Tasks Across Functions

Compressing sequential tasks across functions implies discarding the "assembly-line" approach, and reconfiguring the sequence of the tasks to better exploit the capabilities of I/T. The traditional sequencing of tasks is based on classical management theory of division of labor. BPR eliminates all or some of the steps and assigns a person or a group to be responsible for the resulting single step or group of steps. This single person (or group) is called a "case worker" (or team). The case worker also provides a single point of contact in the organization for the customer, improving quality of customer service. Hammer and Champy (1993) cite IBM Credit Corporation as an illustration of this principle: The corporation compressed a credit application process comprising six

steps and taking six to ten days down to only one step, one person, and taking only ninety minutes.

Second BPR Principle: Compressing Tasks Vertically Within the Managerial Hierarchy

Compressing tasks vertically involves eliminating the need for vertical division of labor. The traditional organization has employees doing the work distinguished from those who monitor and make decisions about it. The managerial role of coordination can be delegated to the worker with the help of I/T. In an example cited by Hammer and Champy (1993), Ford Motor Company illustrated this principle by delegating the need for payment authorization from the accounts payable department down to the receiving dock. This procedure reduced the number of people working in accounts payable from 500 to 125.

Third BPR Principle: Eliminating Slack Resources

Slack resources refer to extra resources available to the organization in handling uncertainty. Slack resources include higher levels of inventory to prevent possibilities of stockouts and multiple supplier contracts to prevent running out of supplies. Hammer and Champy's (1993) example of eliminating slack resource is Ford Motor Company's decision to have only one source of supply instead of maintaining multiple sources of supply for each automobile component. Using I/T, the single supplier had access to Ford's manufacturing schedule, from which it was able to more accurately schedule its own production and reduce the size of its inventory.

Fourth BPR Principle: Reducing the Distance Between the Point Of Decision and the Point of Information or Eliminating Intermediaries

The principle of reducing the distance between the point of decision and the point of information, or eliminating intermediaries, states that organizations no longer need to sacrifice the benefits of economies of scale, coordination, and flexibility because of geographical distance. Using I/T, distributed resources can be treated as though they are centralized (Hammer 1990, 1993). Geographically distributed transactions need to be captured only once and henceforth processed for global consumption. Hammer and Champy's (1993) example of this principle is Hewlett-Packard's use of a central vendor database to perform the purchasing for more than fifty of its decentralized manufacturing facilities. This principle is closely related to another principle -- eliminating intermediaries.

Human intermediaries in any process are inherently inefficient and ineffective. I/T provides two methods of eliminating intermediaries -- automation and direct communication. Automation is the process that eliminates inefficient human intermediaries from a process. Direct communication is the process that eliminates ineffective human intermediaries. Davenport's (1993) example of eliminating intermediaries is the automation of the New York Stock Exchange. Electronic stock trading saves buyers and sellers hundreds of millions of dollars annually. These two principles -- eliminating intermediaries and reducing the distance between the point of decision and the point of information -- are similar and are therefore combined to form the 4th Principle of BPR.

Fifth BPR Principle: Reconfiguring Sequential Process to Operate in Parallel

Reconfiguring sequential processes to operate in parallel not only reduces cycle time, but reduces problems and errors resulting from delays, handoffs, and disruptions in the process. Using I/T to coordinate parallel activities, each self-contained thread within a process is able to take advantage of both its self-containment and the information available from other threads of operation running simultaneously. The information available from parallel threads of operation help the whole organization better track and monitor the process. Davenport's (1993) example of this principle is concurrent engineering.

Sixth BPR Principle: Linking Parallel Activities During the Process

This principle is related to the previous principle, but adds an additional requirement of coordinating and integrating activities during the process, instead of integrating their results at the end of the process (Hammer 1993). Linking parallel activities is crucial to the success of cross-functional teams. I/T can coordinate independent working groups while they are performing their individual tasks, resolving problems before the end of the process, and eliminating possible delays. Again, concurrent engineering is an excellent example of this principle.

BPR and Client/Server Systems

Many studies stress the importance of I/T in BPR. As explained by the six proposed principles of BPR, Hammer and Champy (1993) and Davenport (1993) consider I/T one of the enablers of BPR. At the same time, because of the "downsizing" or

"rightsizing" trend within organizations, workstation-based client/server systems are becoming a major part of their reengineering efforts (Manganelli and Klein 1994; Baxter and Lisburn 1994; Trimmer 1993; Guengerich 1992). Very little research exists that explains the role these client/server systems play, if any, in BPR. Many writings, mostly from the trade literature, attempt to explain the benefits of using client/server systems. The benefits of client/server systems can be summarized as follows:

Reduced Cost of Hardware, Software, and Support Staff

The trade literature reports numerous cases of cost savings as a result of migrating to workstation-based client/servers (Johnson 1992). Hypothetical examples by Renaud (1993), Trimmer (1992), and Kavanaugh (1995) support the possible cost savings from implementing workstation-based client/servers as opposed to centralized mainframe platforms. However, the cost issue is more complex. Berg (1992) reported that moving applications from mainframes to smaller systems could save the organizations 50 percent or more. However many other unexpected costs, such as training costs, labor costs in systems and network management, telecommunications costs, and capacity planning costs, may result in workstation-based client/server applications becoming more expensive than mainframe applications. Kennedy and Gurbaxani (1994) noted that workstation-based client/server platforms cost $700 per MIPS or less, and mainframe MIPS cost $40,000 each. However, support costs for workstation-based client/server applications are 20 to 30 percent more, software costs are about the same, and staffing costs can be much more

than mainframe platforms. Depending on the plan for the BPR, cost issues will be an important factor.

Increased System Performance

Hammer and Champy (1993) note how increasingly affordable computing power is making new applications possible for companies. Workstation-based client/server systems embody this affordable computing power. Renaud (1993) states that 90 percent of a mainframe's processing power is dedicated to input and output, whereas 90 percent of a workstation's processing power is dedicated to the central processing unit. The combination MIPS of a distributed system can be potentially much more than a single mainframe system (Berson 1993). System performance issues are crucial, especially when implementing BPR enabling technologies (Hammer and Champy 1993). These technologies include expert systems, imaging, computer-assisted software engineering (CASE), multimedia, and pen-based computing.

System Extendibility

Henderson and Venkatraman (1993) stress the necessity for the alignment between organizational strategy and I/T strategy. Extendible workstation-based clients/server systems can help organizations achieve this alignment. LeLann (1981) defines distributed system extendibility as a system's ability to adapt to changing environments without disrupting its functions. Environments can change when (1) modifications are made to improve performance, and (2) modifications are made to change services provided. When

performance needs to be improved in a distributed system, specific processing elements can be added or replaced. System configuration can be made more efficient by reducing the number of components. Similarly, services provided by distributed systems can be changed more easily than in centralized systems, especially if the system was designed from the beginning to be modular. It is this extendible characteristic of client/server systems that contributes to their flexibility and scalability (Dewire 1993). In order for I/T to enable BPR, changes may need to be performed on the I/T architecture (Davenport 1993; Hammer and Champy 1993; Henderson and Venkatraman 1993). Client/server extendibility will contribute to this requirement.

Increased System Availability

The distributed architecture allows the existence of mutual inspection systems that perform automatic detection, diagnosis, and recovery. If these systems cooperate in a decentralized manner without relying on a single central processing element, they can take advantage of full redundancy in hardware, software, and data. This decentralized cooperation results in a fail-safe computing environment (LeLann 1981; Cashin 1993).

Better Resource Sharing

Hammer and Champy propose the use of shared databases and telecommunication networks so businesses can share each other's resources, and "information can appear simultaneously in as many places as it is needed" (Hammer and Champy 1993, 92).

Client/server systems' inherent capability is resource sharing and communications (Dewire 1993; Sinha 1992).

Local Autonomy and Employee Empowerment

The user of a client/server system has more control over the application compared to batch systems or even on-line interactive systems (Renaud 1993). Client/server architectures offer user empowerment, which promotes user motivation, and reduces user resistance toward organizational changes (Kappelman and Guynes 1995).

Processing Load Balancing and Optimal Network Utilization

Client/server systems balance processing loads by allowing the processing to reside close to the data. Therefore, network traffic and response time can be reduced, and the network's carrying capacity and throughput can be increased (Sinha 1992; Dewire 1993). This efficient use of resources makes the client/server interaction model an attractive solution for many memory/processing intensive BPR-enabling applications. These application include expert systems, image data management systems, fuzzy logic, full text retrieval systems, distributed heterogeneous databases, multimedia, CASE and pen-based computing (Hammer and Champy 1993).

Enhanced Access to Data, Services, and Applications

Client/server systems offer enhanced access to data, services, and applications, regardless of where the user may be located (Renaud 1993; Smith 1992). According to Hammer and Champy (1993), this enhanced access should enable a generalist to do the

work of an expert. By giving better access to data, services, and applications to a case worker, the organization can achieve an order-of-magnitude improvement in cycle time, accuracy, and cost (Hammer and Champy 1993). This increased access should also enable more workers in the organization to make decisions, rather than just the manager (Hammer and Champy 1993), thereby empowering the worker. Also, using client/server technology, field personnel can send and receive information wherever they may be (Hammer and Champy 1993).

Application-Independent and Easy-to-Use Graphical User Interface

The client/server's ability to optimally manage processing loads means that users can make use of advanced memory-intensive and processing-intensive graphical user interfaces (GUI) at the workstations (Berson 1993; Dewire 1993). GUIs contribute to increased user control (Renaud 1993) and improved productivity (Dewire 1993). Increased user control and improved productivity translate to user satisfaction, increased user motivation, and reduced user resistance toward organizational changes that are part of BPR (Kappelman and Guynes 1995).

Improved System Interoperability

BPR can mean sharing information among heterogeneous platforms (Hammer and Champy 1993) and using interorganizational communications (Davenport 1993). Client/servers improve system interoperability by encouraging the development of

standards and improving connectivity among vendors (Berson 1993, Renaud 1993; Dewire 1993).

There is very little empirical research to support any of the above claims for the benefits of client/server systems. The focus of this study is to show how enhanced access to data, services, and applications facilitates BPR.

Paradigms for Studying Business Process Reengineering

Davenport (1993) traces the roots of BPR to organizational design efforts such as the quality movement, industrial engineering, systems theory, the work design approaches pioneered by the sociotechnical school, studies in diffusion of technological innovation, and competitive uses of I/T. Huber and McDaniel (1986) categorize these and other organizational design movements into four paradigms: (1) the paternalistic/political paradigm, (2) the accountability/authority paradigm, (3) the workflow paradigm and, (4) the decision-making paradigm.

The paternalistic/political paradigm focuses on allocating power-enhancing resources, such as authority and subordinates, to people who are likely to be loyal supporters because of kinship or political affiliation. The criterion for organizational effectiveness associated with this paradigm is the maximization of the leader's political power. This paradigm was central to the pre-scientific management school, prior to the beginning of the twentieth century.

The accountability/authority paradigm focuses on specifying who is accountable for fulfilling which responsibilities and to allocate, to those accountable, sufficient

authority to enable them to carry out their responsibilities. The criterion for organizational effectiveness is the maximization of the probability that those who are assigned responsibilities fulfill those responsibilities. This paradigm was central to the classical management school. Examples of the various orientations of classical management (French and Bell 1990) are administrative theory (Fayol 1949), scientific management (Gilbreth 1912; Taylor 1911), and the structuralist school (Weber 1947).

The workflow paradigm focuses on creating structures and administrative processes that match the organization's production or operations. The criterion for organizational effectiveness is the maximization of either the production system or the joint effectiveness of the production system and the structural system together. This paradigm is central to the sociotechnical systems design concepts (Trist 1981; Woodward 1965).

The decision-making paradigm, according to Huber and McDaniel (1986), focuses on designing organizations that facilitate the making of organizational decisions. The criterion for organizational effectiveness is maximization of the quality of decisions made. Huber and McDaniel (1986) argue that this paradigm is more suitable than the other three paradigms because of recent changes in both cultural and economic spheres. Organizational environments in this postindustrial era are becoming more hostile, complex and turbulent. This more turbulent environment requires decision making to be performed more frequently and more rapidly. Hence, a new paradigm that focuses on decision making is necessary (Huber and McDaniel 1986).

Although this study agrees that the decision-making paradigm is suitable for today's organizations, this paradigm lacks richness and maturity. Another paradigm called the information processing paradigm, also discussed by Huber and McDaniel (1986), is the choice of this study. The information processing paradigm should be treated as complementary to the decision-making paradigm, because decision making is closely related to the amount and the quality of information available to the organization.

The relationship of decision making and information has been studied as early as the 1950s. Simon's (1955) concept of rational and nonrational behavior, and maximizing behavior in decision making, has prompted many writers to theorize the relationship between information and decision making. For example, the concept of maximizing behavior assumes that an "economic man" must therefore be "rational." It also assumes that the economic man has information concerning all relevant aspects of his environment, and has the ability to choose alternative courses of action that permit him to get the best of his preferences (Simon 1957). Most writers disagree with this concept for three major reasons (Harrison 1975): First, evidence has shown that the decision makers are not pursuing maximization of the objectives of the organization; rather, they behave to maintain the status quo and to maximize their own utilities. Second, with the divergence of interests, loyalties, and objectives among the decision makers, it is unlikely that the firm will maximize its objectives. Third, limitations of information, resources, law, and convention make it impossible for the firm to maximize behavior (Harrison 1975). Simon (1957) also introduced the term "bounded rationality." Simon noted that:

> The capacity for formulating and solving complex problems is small compared with the size of the problems whose solution is required for objectively rational behavior in the real world (Simon 1957, 198).

Thus, as the decision maker receives various information to make his or her decision, the ability to receive information is constrained by (1) his or her own intellectual capability, (2) the scarce resources available for searching relevant alternatives, and (3) the impossibility of getting perfect information, even with limitless time and money (Harrison 1975). Also, as more amounts of information are obtained, the marginal value of additional information decreases. After the search is completed and the limits of the decision maker's cognitive abilities is reached, the decision maker formulates a few relevant alternatives and makes what Simon terms a "satisficing choice" (March and Simon 1958). Because of the close relationship between information and decision making, the information processing paradigm is chosen as the basis for this research.

The Information Processing Paradigm

The information processing approach has been given increasing attention by various researchers (Daft and Lengel 1986; Sviokla 1989; Goodhue et al. 1992; Kambil 1993). Galbraith (1977) developed this approach as a basis for choosing alternative organizational forms. Galbraith proposed that organizations must design actions to reduce the need for information, or to increase the information processing capacity of that organization. Galbraith (1977) delineated five major interrelated elements that

affect the amount of information processing of the organization as shown in figure 3.

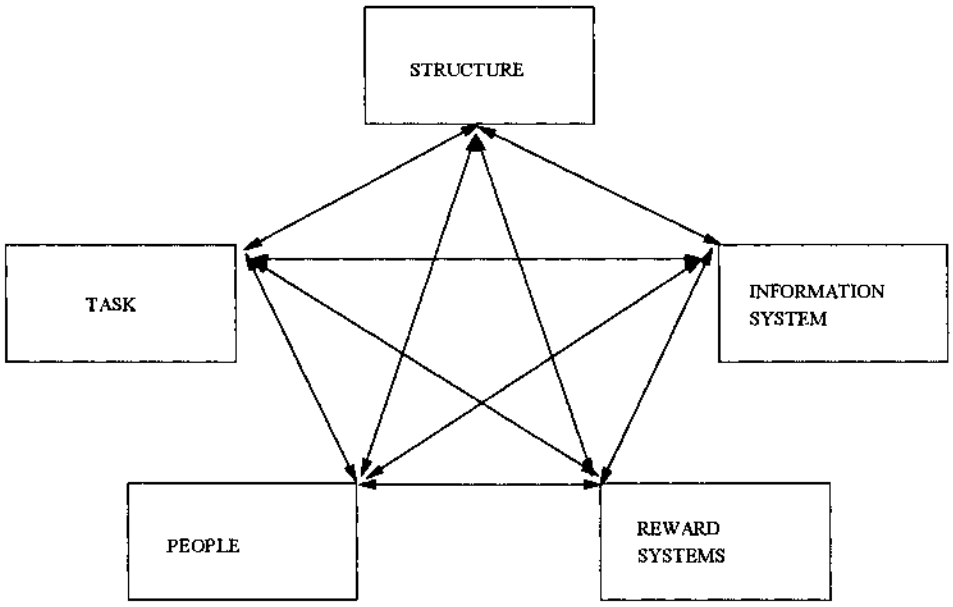

Fig. 3. Organization design variables. Adapted from Galbraith (1977)

Galbraith defines "organization design" as the "decision process to bring about a coherence between the goals or purposes for which the organization exists, the patterns of division of labor and inter-unit coordination and the people who will do the work" (Galbraith 1977, 5). The need to balance these three elements (strategy, organizing mode, and integration of people) is translated into an information processing model consisting of the five elements of (1) task, (2) structure, (3) information system, (4) reward system, and (5) people. Figure 3 describes the linkages that exist among these five components.

Each component has its own attributes. Changes in the attributes of any one

component will affect the attributes of the other components. This model can be discussed from the point of view of any of the five components. For example, task can be characterized by degree of uncertainty. Uncertainty is defined by Galbraith as "the difference between the amount of information required to perform the task and the amount of information already possessed by the organization" (Galbraith 1977, 36). Galbraith proposed that "the greater the task uncertainty, the greater the amount of information that must be processed among decision makers during task execution to achieve a given level of performance" (Galbraith 1977, 36). Hence, referring to figure 3, if the task uncertainty increases (e.g., as a result of increasing the number of products manufactured), the structure of the organization may need to change to reduce the information required to process that increase in uncertainty. Similarly, the information system may need to be reconfigured to process more information to maintain a given level of performance. The people may need to be retrained, and the reward system may need to be changed to maintain the required level of motivation to match with the increase in the level of task uncertainty.

This information processing paradigm is closely related to the decision-making paradigm because decision making is closely related to the amount and quality of information. In fact, the concept of uncertainty discussed by Galbraith (1977) centers around the need for organizations to make decisions based on the information available to them. If such information is unavailable, uncertainty increases. The information processing paradigm has the necessary richness and robustness for researchers to

understand the requirements and functions of coordinative structures employed by the organization. The information processing paradigm can be modeled as shown in figure 4.

Galbraith (1977) proposed five strategic alternatives that reduce uncertainty, the first three of which reduce the information processing required, while the other two increase the organization's capacity to process more information. The five alternatives are:

1. Managing the external environment
2. Creating slack resources
3. Creating self-contained tasks
4. Creating lateral relations
5. Investing in vertical information systems.

Managing the External Environment

Galbraith (1977) defines the external environment of the organization as consisting of consumers, suppliers, competitors, and regulatory groups. Choices that the organization makes concerning strategy, technology, and location determine the organization's environment. Assuming that the organization has chosen its strategy, technology, and location, Galbraith (1977) proposes several strategies by which the organization can reduce uncertainty and/or dependence on its environment.

These strategies include becoming more competitive, establishing a more favorable public image, voluntarily managing issues related to the organization, cooperating with

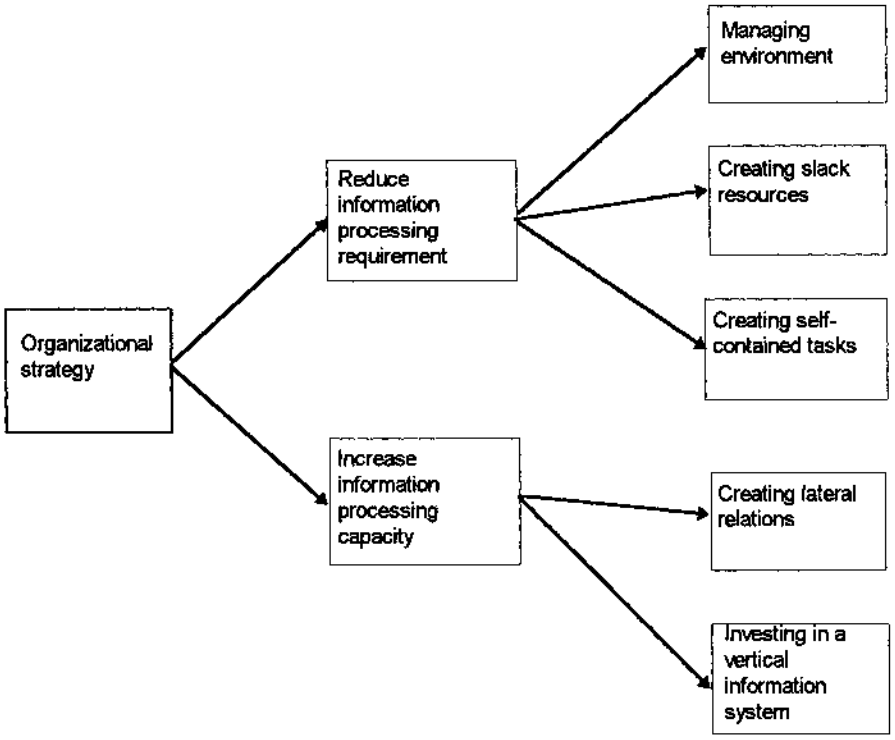

Fig. 4. Information processing model. Adapted from Galbraith (1977)

other organizations, merging with other organizations, and forming coalitions and strategic alliances. Galbraith's (1977) concept of managing the external environment is similar to Henderson and Venkatraman's (1993) concept of business governance. Henderson and Venkatraman (1993) define business governance as man-made institutions created for managing uncertain exchange relations in a setting of interdependence. Such institutions include strategic alliances, joint ventures, marketing exchanges, and technology leasing (Henderson and Venkatraman 1993). The ultimate objective of

managing the environment is to reduce the level of uncertainty that confronts the organization (Galbraith 1977).

Creating Slack Resources

Creation of slack occurs when the organization responds to problems by increasing the resources available, rather than utilizing existing resources more efficiently. For example, in order to satisfy customer requirements, the sales department may respond by increasing inventory levels rather than risk the possibility of stockouts. Creation of slack reduces complexity and hence the level of information processing required. The disadvantage of this strategy is the increased possibility of waste and spoilage.

Creating Self-Contained Tasks

Self-contained tasks are organizational institutions dedicated to a category of output and contain all major resources needed to provide for that output. Examples of typical implementations of self-contained tasks include organizing around major sections of a product, product line, or geographical area. The effect of self-contained tasks is to reduce information processing by reducing the following elements (Galbraith 1977):

1. The amount of output diversity of each process:

   Reducing the output diversity reduces the need to share resources and the level of exceptions that need to be processed.

2. The division of labor:

   Reducing the division of labor is achieved by creating processes and mechanisms to handle the information processing, hence reducing the number of exceptions that need to be processed between functions or within the managerial hierarchy.

3. Reducing the distance between the point of decision and the point of information: Giving those employees who handle pertinent information more autonomy, thereby achieving "local discretion" based on available information.

Creating Lateral Relations

Creating lateral relations is defined as workers solving problems at their own level, contacting and cooperating with peers in those departments affected by the new information. Examples of lateral relations include direct-contact liaisons, tasks forces, and teams (Galbraith 1977).

Investing in the Vertical Information System

Investing in vertical information systems is defined as increasing the capacity of existing channels of communication, creating new channels, and introducing new decision mechanisms (Galbraith 1977). Although Galbraith's emphasis was on increasing the capacity of information within the managerial hierarchy, the same concept does not preclude the possibility of between-function channels of communication.

Based on the information processing model of Galbraith (1977), Sviokla (1989) defined three variables that could be used to measure the level of uncertainty: (1) number

of inputs, (2) diversity of outputs, and (3) the level of performance required by the business process. Daft and Lengel (1986) and Tushman and Nadler (1978) summarized Galbraith's information processing approach into a model for organizational effectiveness.

Emphasizing Galbraith's assertions, Tushman and Nadler (1978) and Daft and Lengel (1986) propose that organizations will be more effective when there is a match or "fit" between information processing requirements facing the organization and information processing capacity of the organization's structure. Daft and Lengel extended the concept of uncertainty to include equivocality. Equivocal information is ambiguous information that can lead to multiple and divergent interpretations by the people in the organization. Daft and Lengel also proposed that organizations should increase not only the amount of information, but also the "richness" of information. Richness of information is based on the amount of feedback that is possible, the number and type of cues available (physical appearance, voice inflexion, body language), the variety of language conveyed (natural language as opposed to computer symbols), and personal focus (or customization of the information).

The conclusions from Robey (1981), Olson (1982), Foster and Flynn (1984), and George and King (1991) support Galbraith's information processing approach. Robey's (1981) assertion that I/T is a moderating variable rather than an independent variable fits Galbraith's (1977) model shown in figure 3. Robey's (1982) moderating variable model is similar to George and King's (1991) assertion that a number of variables act simultaneously to produce the eventual outcome. Both Robey (1981) and Foster and

Flynn (1984) discuss changes in "lateral relations" in the form of new communication channels and new forms of reporting relationships as a result of I/T implementation. Creation of lateral relations and reporting relationships fit the description given by Galbraith (1977).

BPR Principles and the Information Processing Model

The six principles of BPR can be related directly to the information processing model developed by Galbraith (1977) as shown in figure 4. At least one or more of the principles discussed above can be implemented in each of Galbraith's (1977) five strategic choices to reduce information processing requirement or increase information processing capacity:

1. Managing the external environment
2. Creating slack resources
3. Creating self-contained tasks
4. Creating lateral relations
5. Investing in vertical information systems.

Figure 5 shows the relationship between the strategic choices proposed by Galbraith's information processing model and BPR.

Managing the External Environment and BPR's First, Second, Third, and Fourth Principles

An example of BPR in the context of managing the external environment is the combination of electronic data interchange (EDI) with supply processes (e.g., shipments

and inventory management) or with market processes to accomplish just-in-time (JIT) inventory (Davenport 1993; Venkatraman and Zaheer 1990). In the manufacturing industry, logistical processes can be reengineered by using components from third parties to offload manufacturing tasks. Using just-in-time delivery to avoid holding inventory, these components are packaged to suit customer requirements (Davenport 1993).

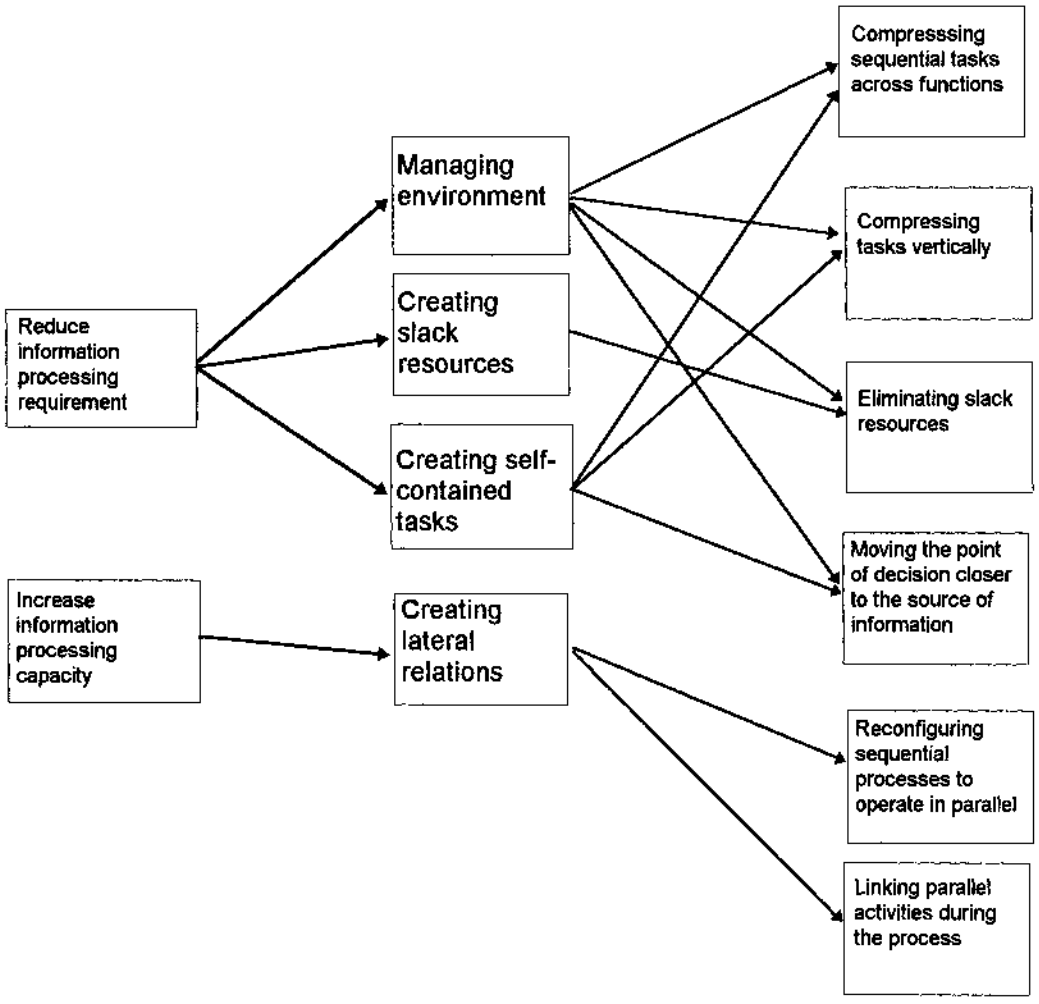

Fig. 5: BPR and the information processing model

EDI creates a direct link between buyer and seller organizations, which reduces the need for an elaborate purchasing or requisition function. This direct link compresses sequential tasks across functions (first BPR principle) and eliminates intermediaries (fourth BPR principle). With EDI, many authorization-type tasks can be delegated to the EDI mechanism itself, thereby compressing vertical tasks (second BPR principle). JIT eliminates slack resources like buffer inventories and reduces shipping lead-times (third BPR principle).

Creating Slack Resources and BPR's Third Principle

The creation of slack resources is being replaced by less costly alternatives, such as vertical information systems (JIT delivery, and highly efficient materials requisitioning processes). These systems eliminate slack resources (third BPR principle).

Creating Self-Contained Tasks and BPR's First, Second, and Fourth Principles

An example of BPR using the concept of self-contained tasks is the reduction in the division of labor achieved by compressing or combining several steps of a lengthy process into one integrated job, performed by a single person or a group (first BPR principle). Compressing the steps in a process should not just be performed sequentially across tasks, but also vertically at points where the worker is forced to go up the managerial hierarchy for a decision (second BPR principle). Hammer describes this approach as organizing "around outcomes, not tasks" (Hammer 1990, 108). Creating the

self-contained tasks should result in fewer delays, lower overhead costs, better customer response, and greater empowerment for workers (Hammer and Champy 1993).

Galbraith (1977) proposes that by placing the necessary mechanisms and information processes at the disposal of the workers, less information processing will be required. Typical I/T mechanisms that could play that role include decision support systems and expert systems that help make decision making a part of every worker's task, not just managers (Hammer and Champy 1993).

Another method of creating self-contained tasks is to move the point of decision closer to the source of information (fourth BPR principle). Hammer describes this concept as having "those who use the output of the process perform the process" (Hammer, 1993, 109) and putting "the decision point where the work is performed" (Hammer 1993, 111). The effect is similar -- information and exceptions need to travel through fewer levels before reaching a shared superior, and more decisions can be made at lower levels, in self-contained units.

Creating Lateral Relations and BPR's Fifth and Sixth Principles

In the BPR context, several strategies fit the description of creating lateral relations (Hammer 1993; Davenport 1993):

1. Changing process sequence, or enabling parallelism to achieve reductions in cycle-time. Lateral relations are built between parallel process sequences (fifth BPR principle).

2. Linking parallel activities during the process instead of integrating their decisions after the process is completed. Lateral relations are employed to coordinate and link parallel activities (sixth BPR principle).

Investing in Vertical Information Systems and BPR

Although information systems have traditionally been employed to increase the information processing capacity of organizations, it cannot be assumed that information systems will always create changes in business processes. The information system could be merely an electronic version of the manual process, in which case, no business process change has taken place. A typical example of this absence of change is the use of computer-based word processors as electronic typewriters. Galbraith (1977) however, used the term "vertical" information systems, to suggest the use of information systems across hierarchical boundaries in the organization. In this study, the increase in capacity to process information (or reduction in the need to process information) is achieved as a result of implementing any or all of the earlier four methods of organizational design using information systems.

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CHAPTER 3

THEORETICAL FRAMEWORK

This chapter proposes the initial theory for the study and develops a research framework for studying the role of workstation-based client/server systems in changing business processes. In performing case study research, Yin (1989) and Eisenhardt (1989) stress the importance of specifying constructs prior to data collection. Therefore, the identification of constructs and variables is the objective of this chapter. The research framework that is developed in this chapter enabled the researcher to determine what variables needed to be explored, the purpose of the exploration, and the criteria by which the exploration is judged successful (Yin 1989).

The research framework is developed based on an emergent perspective (Markus and Robey 1988) of organizational change. That emergent perspective is coupled with a process theory approach and a business process level of analysis (Markus and Robey 1988). These approaches to studying organizational change are made possible using network analysis techniques (Knoke and Kuklinski 1982). Using the research framework, nine propositions (p. 83) surrounding the relationship between client/server implementation and business process redesign are proposed.

Organizational Change Theory

The theoretical substance behind this study is based on the emergent perspective of organizational change, process theory, and a mixture of micro and macro level of analysis (Markus and Robey 1988). The emergent perspective argues that organizational change emerges from the complex interaction of people and events, rather than as a consequence of any set of independent variables. This perspective rejects the technological imperative or the organizational imperative of organizational change. The technological imperative views technology as the *independent* variable that determines the behavior of individuals and organizations. The technological imperative is reflected in Leavitt and Whisler's (1958) study about the impact of computers on the organization. The organizational imperative, on the other hand, views information technology as the *dependent* variable, caused by the organization's information needs and the people's choices about how to satisfy them.

Although Markus and Robey (1988) contend that Galbraith's (1977) information processing model fits the organizational imperative approach, this is far from true. Galbraith (1977) did not indicate the direction of the causal flow. He only stated that if any of his five elements (as shown in figure 3) were to change, the other four elements might need to be readjusted to accommodate that change. Galbraith's (1977) model fits more into the emergent perspective as defined by Markus and Robey (1988). The emergent perspective contends that organizational change emerges from the complex interaction of people and events, making the prediction of behavior difficult. This study's research framework therefore considers the technology and the other four components of

Galbraith's (1977) model as moderating variables that interact to cause the business process change.

Another aspect of the theory behind this study is the use of process theory to explain organizational change. Process theory (Mohr 1982) states that no single independent variable is necessary and sufficient for explaining organizational change. This approach rejects the variance theory approach. The variance theory approach states that a single independent variable can be both necessary *and* sufficient for change to occur. Although a conscious intent must exist before any deliberate change is possible (George and King 1991), the intent to change the organization is *not* a necessary or sufficient condition for the business process to change: it is only necessary for the change to occur. The use of this process theory approach preserves the study's belief in the regularity and predictability of social phenomena (thereby making generalizations for this research possible), but avoids the simplistic variance theory approach used by other social research studies (Mohr 1982).

Research Framework

A framework is defined as a skeletal or basic structure of ideas, objects, variables, and their interrelationships regarding a field, subject, or area of research (Kochen 1985). Frameworks facilitate, and perhaps ratify, the development of a consensus among information systems (I/S) scholars concerning the body of phenomena constituting the subject matter of I/S -- therefore fulfilling the stages of scientific progress (Cushing 1990). Frameworks partition the world of experience and ideas into manageable parts. This

process facilitates the "chunking" behavior of individual researchers so that they can make good use of limited memory and other cognitive capacities. Frameworks organize what is known in a field for research and teaching, and help other researchers to analyze the research. In the context of this case study, frameworks verify that the necessary and appropriate variables and linkages have been included and that the variables and linkages fit. Frameworks in this study help the researcher choose significant elements to investigate and help the researcher set priorities. A suitable framework should be made up of the elements of interest, linkages, and relationships between the elements of interest, and where the research falls within the overall framework of management information systems (Kochen 1985).

The framework for this research is shown in figure 6. The framework is a combination of the information processing model (Galbraith 1977) and the six BPR principles explained in chapter 2. The research framework shows that managerial action affects business process change by reducing uncertainty. Managerial action is the independent variable, and business process change is the dependent variable. Studies by Galbraith (1977), Robey (1981), George and King (1991), and Henderson and Venkatraman (1993) suggest that managerial action should be the independent variable. Since the objective of this study is to investigate the role of client/server systems in changing business processes, the underlying themes that represent business process change become the dependent variables. The six themes or "principles" of business process change are derived from studies by Davenport (1993), Hammer (1990), Hammer and

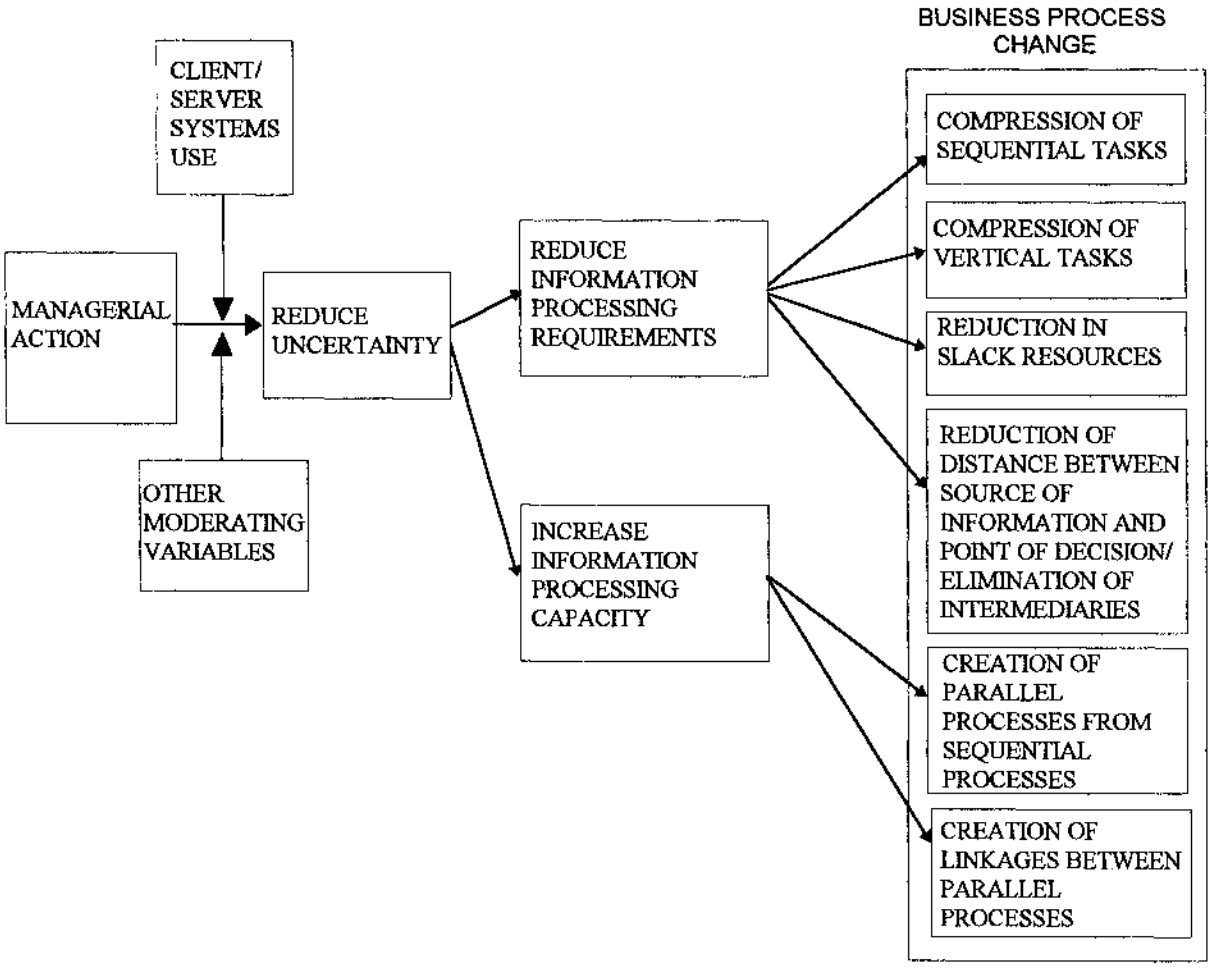

Fig. 6. Research framework

Champy (1993), and Venkatraman (1991). The variables that fall between the independent and dependent variables are derived from Galbraith (1977), as explained in chapter 2.

The research framework shows intervening and moderating variables in addition to independent and dependent variables. Uncertainty is an intervening variable in the framework. An intervening variable is defined as a variable that theoretically affects the dependent variable but cannot be seen, measured accurately, or manipulated (Emory 1985). Baron and Kenny (1986) define an intervening variable as a variable that accounts for the relation between the independent and dependent variable. The research framework suggests that any change in business processes is achieved as a result of reducing uncertainty.

The research framework in figure 6 shows uncertainty as a result of two intertwined strategies: reducing information processing requirements and increasing information processing capacity. This assumption is based on Galbraith's information processing model. Uncertainty is defined by Galbraith (1977), and Daft and Lengel (1986), as the difference between the amount (and richness) of information processing required and the amount (and richness) of information processing already possessed by the organization. In other words, uncertainty is the amount and richness of information that needs to be acquired.

Uncertainty is determined by two offsetting components, as shown in figure 7. Information processing requirements are shown on the left side. The combination of information processing already possessed and information processing that needs to be acquired by the organization (i.e., uncertainty), are shown on the right. Assuming that the amount of information that the organization possesses remains the same, any reorganization that reduces the information processing requirement will decrease

uncertainty. If the organization decides to increase uncertainty (e.g., by tightening budgets or embarking on a new product line), the amount and richness of information that is required increases. Assuming that the organization has not changed, this increase in uncertainty needs to be offset by an increase in information processing capacity.

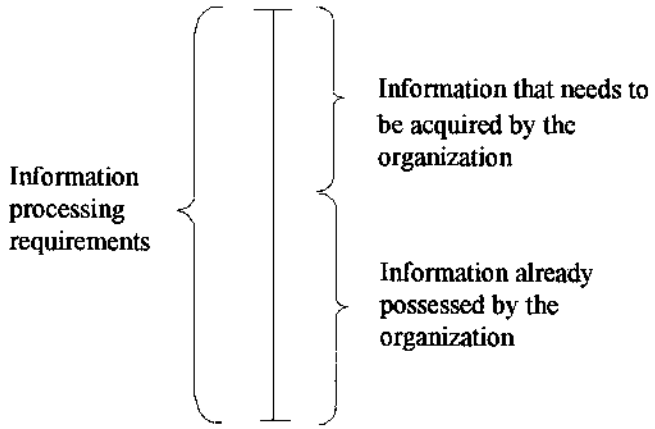

Fig. 7. Information processing capacity and requirement.
Adapted from Galbraith (1977)

The change in the level of uncertainty can be measured using three variables (Galbraith 1977; Sviokla 1989): (1) diversity of outputs, (2) number of inputs and, (3) the level of performance required by the business process. Change in any one or more of these three variables will suggest that uncertainty has been reduced. The direction of change at this point is *not* indicative of whether uncertainty has been reduced or increased, because an increase in uncertainty in one area may be offset by a reduction of uncertainty in another area. In order to identify the direction of change in uncertainty, the research

framework recognizes that different strategies affect uncertainty differently. The strategies that reduce information processing required, in the context of changing business processes are managing the external environment, eliminating slack resources, and creating self-contained tasks. The strategies that increase information processing capacity are reconfiguring sequential processes to operate in parallel, and linking parallel tasks during the process.

In the research framework, the reduction of uncertainty is moderated by the use of workstation-based client/server systems, and by other variables (collectively labeled "OTHER MODERATING VARIABLES"). A moderating variable is defined as a variable that affects the direction and/or strength of the relation between the independent and dependent variable (Baron and Kenny 1986). The choice of including moderating variables in the research framework is based on studies by Galbraith (1977), Robey (1981), Markus and Robey (1988), and George and King (1991). The framework proposes that using workstation-based client/server systems will facilitate changing business processes by either reducing information processing requirement or increasing information processing capacity. The constructs that represent change in business processes, resulting from a reduction of information processing required, are one or any combination of these four BPR principles: (1) compression of sequential tasks, (2) compression of vertical tasks, (3) reduction in slack resources, or (4) reduction of distance between source of information and point of decision/elimination of intermediaries. The constructs that represent change in business processes resulting from an increase in

information processing capacity are either (1) creation of parallel processes from sequential processes, or (2) creation of linkages between parallel processes, or (3) both.

Client/Server Systems Use as a Moderating Variable

The moderating variable, client/server system use, can be represented by the potential effects it has on the organization. These potential effects are the result of the benefits of using client/server systems. The benefits of using client/server systems, as explained in chapter 2, are (1) cost of hardware, software and support staff, (2) increased system performance, (3) system extendibility, (4) increased system availability, (5) better resource sharing, (6) local autonomy and employee empowerment, (7) processing load balancing and optimal network utilization, (8) enhanced access to data, services, and applications, (9) application-independent and easy-to-use graphical user interface, and (10) improved system interoperability. The focus of this research is on the benefits from enhanced access to data, services, and applications.

Galbraith (1977) suggests several ways of characterizing information systems. One particular characteristic, "the scope of the database," can be used as a surrogate for the benefits of enhanced access. Galbraith (1997) defines the scope of the database as the extent of access to information available to decision mechanisms in the organization. The level of access to information affects the ability to make activities in one part of the organization consistent with activities taking place in the other parts of the organization. If the decision mechanism has access to information pertaining to its immediate location, the scope is restricted (i.e., it is local). On the other hand, if the decision mechanism has

access to information from all functional departments and concerning all outputs, the scope is wider (i.e., it is global). For example, the scope of the database can be increased by creating direct information channels to a position in the hierarchy that has a wider influence on the outcomes of the organization. The greater the scope of the database, the greater the capacity to process information. An example will illustrate how the framework describes the effects of workstation-based client/server systems implementation in changing business processes.

A network diagram, shown in figure 8, displays the relationships that exist in a business process (Knoke and Kuklinski 1982). Assuming that a business process involves

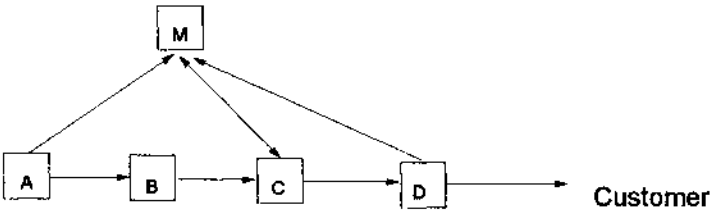

Fig. 8: Network diagram before redesign

a manager M, and four other employees (A, B, C and D), the directed lines linking the decision mechanisms (the manager and the employees) are information channels used for decision making purposes. The presence of these linkages means that communication channels are being utilized to carry information to complete the task by the parties

involved. A unidirectional arrow points to the receiver of that information. A bidirectional arrow implies that the parties at both ends send and receive information.

The organization decides to reengineer this business process. The organization could retrain employee A to perform the tasks normally performed by employees B, C,

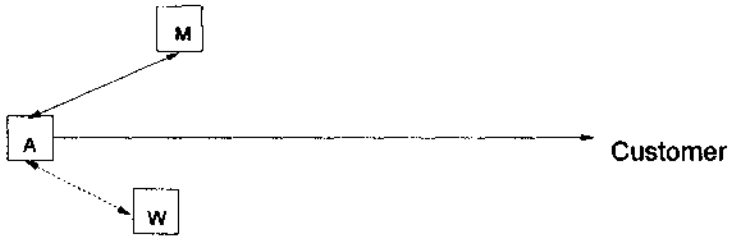

Fig. 9: Network diagram after redesign

and D. By doing so, the organization has reduced division of labor and reduced the need for sharing information and the need to coordinate and schedule resources. The result is to reduce the number of exceptions that have to travel to the manager (Galbraith 1977). This reduction is possible because employee A has acquired the information processing capacity of B, C, and D. Although the information processing capacity of employee A has increased, the overall information processing required by the business process has decreased, because there is no longer any need to share information or coordinate and schedule resources. In this situation, the decrease in information processing required can be attributed to the training of employee A, assuming everything else remains the same. Instead of extensively training employee A to perform the tasks normally performed by

employees B, C, and D, the organization could use information technology to perform part of those tasks. The linkage between employee A and the new information technology is shown using dotted lines (figure 9). The result is the same, except that since no training has taken place, the decrease in information processing required can be attributed to the new decision mechanism. The reduction in information processing required enables the organization to replace employees B, C, and D with employee A, and a new decision mechanism. Of course, in a more complex situation where other organizational development strategies (e.g., job enrichment, self-managing teams) are involved, the analysis will not be as trivial.

Network Analysis

The use of a network diagram in the previous section is an illustration of a technique called network analysis (Knoke and Kuklinski 1982). This study employs network analysis concepts to describe the relationship between client/server systems and organizations, and to develop a set of propositions for investigation. Network analysis emphasizes relations that connect individuals or groups within an organization, thereby allowing researchers to draw a systematic picture of social structures and their components. This methodology is highly suited for analyzing possible changes in business reengineering efforts. Network analysis can help highlight entire social structures, as well as comprehend particular elements within the structure. This dual-objective capability of network analysis enables the research to study the variables at different levels of analysis (micro- and macro-level analysis).

Knoke and Kuklinski (1982) describe in detail the basis of network analysis and its application in social studies. Relations are building blocks of network analysis. A network is defined as a specific type of relation linking a defined set of actors (persons, objects, or events). An actor in this study is defined as any individual or group of individuals that are involved in the network of relations. A relation is not an inherent characteristic of any actor in the network; rather, it is an emergent property of the linkage between the actors involved. The structure of relations among actors in a network therefore has "important behavioral, perceptual, and attitudinal consequences" for the actors, as well as for the whole system (Knoke and Kuklinski 1982, 13). Relations have properties (e.g., intensity or strength of a relation) and also, different contents (e.g. transactional, communicational, instrumental, sentimental, authority/power, and kinship). In this study, the strength of the relation refers to the frequency of contacts that take place between any two actors in the relation. This study uses communication as the type of relational content that will be measured. Studying a specific content in a network will yield different results from other contents, even within the same network. Communication content is defined as the information that individuals require in order to generate the product or service of a particular business process.

Networks can be analyzed at different levels: the simplest egocentric level (which concentrates on a node and its relations); the dyad (which concentrates on the relationship formed by a pair of nodes); the triad (which concentrates on the relationships among three nodes); and the complete network (beyond the triad). This study uses the complete level of analysis rather than the egocentric or dyadic level of analysis. This level patterns the

ties among all actors to ascertain the existence of distinct roles within the system. Several other network analysis concepts are used in this study. The network diagram (a two-dimensional diagram displaying the relations observed among actors in a system), the matrix representation of networks, and accompanying matrix indices enable this study to measure the variables depicted in the research framework.

The matrix representation of a network diagram, denoted by a capital letter (e.g., A), enables the study to analyze the data collected more closely than does a diagram. In a matrix, the actors arrayed in the matrix rows are initiators of the specified relation and the actors arrayed in the matrix columns are recipients of the relation. The subscripts i and j, which take integer values from 1 to N (the sample size) are used to reference the elements appearing in the i^{th} and j^{th} column of a matrix. This study assumes reciprocated relations; thus the element in row i and column j is identical to the element in row j, column i, and the matrix A is symmetric. The list of network analysis measures used in this study is described in detail in the next section.

Criteria for Interpreting Findings

Table 1 details the list of constructs, variables, and measures for the research framework shown in figure 6. The first row of table 1 contains the independent variable, managerial action. This variable is identified by the "management's action to redesign

Table 1. -- Constructs, variables, surrogates and measures for the study

Constructs	Independent Variable	Surrogates	Measures
Business strategy	Managerial action		Management's action to redesign or reengineer business process using client/server technology
	Moderating Variables		Measures
Use of workstation-based client/server systems within the redesigned business process as defined by the organization	Client/server system use	Scope of the database	Centrality of workstation-based client/server system
	Intervening Variables	Surrogates	Measures
	Uncertainty	Output diversity produced by business process	The change in the number of different versions of product/service
		Number of inputs in the business process	The change in the frequency of mutual direct contacts between individuals involved in the business process
		Level of performance generated by business process	The change in the total level of activity generated by individuals involved in the business process

Table 1. -- Continued

Construct	Dependent Variables	Measures
Degree of change in business process	Compression of sequential tasks	The change in the number of employees involved in the sequential tasks across functions
	Compression of tasks vertically up the managerial hierarchy	The change in the number of employees involved vertically up the managerial hierarchy
	Reduction in slack resources	The change in the amount of slack measured quantitatively (e.g., time, level of inventory, number of suppliers)
	Reduction of the distance between the source of information and the point of decision/Elimination of intermediaries	The change in the reachability index between the point of information and the point of decision
	Creation of parallel processes from sequential processes	The change in the number of concurrent activities that would not have existed without client/server systems
	Creation of linkages between parallel processes	The change in the number of direct linkages between concurrent activities

or reengineer the business process." This intent was used to identify suitable research sites. The moderating variable, client/server systems use, is represented by the surrogate termed database scope, which in turn is measured using the centrality of the client/server system. Centrality, a network analysis metric (Knoke and Kuklinski 1982), is defined as a measure of the degree of involvement of a node in all the network relations. The centrality

index is the ratio of the aggregate relations involving the client/server over all relations in the business process. The formula used in this study for centrality is:

$$Ci = \frac{\sum_{j=1}^{N} (z_{ij} + z_{ji})}{\sum_{i=1}^{N} \sum_{j=1}^{N} z_{ij}} \quad i \neq j$$

where C_i is the centrality of the *i*th actor
z_{ij} represents the value of a relation from the *i*th actor directed to the *j*th actor in the *k*th network
N is the number of actors in the network

As discussed in a previous section, uncertainty has two dimensions: information processing requirement and information processing capacity. As these are two dimensions of the same intervening variable, this study assumes that the same measures can be used for both dimensions. Three surrogates are used to represent uncertainty. Output diversity is measured by the number of versions of the product/service required to be produced by the business process. Number of inputs is measured by the frequency of asymmetric (bidirectional) direct contacts between people that need to be consulted for completion of the business process. Level of performance is the performance required of the people involved in the business process as measured by the total level of activity generated by the individuals involved in the business process.

Total level of activity can be measured in various ways, depending on the case being investigated. In a programming environment, the total level of activity can be the number of lines of code that must be manually generated by individuals, or the total number of reports that individuals need to generate, or the total number of decisions that

individuals need to make. It is assumed that if information processing requirement has increased, this increase can be measured by observing the change in the level of activity. If the implementation of a client/server system has taken up some of the need to generate this level of activity (e.g., in the case of automation), the total level of activity generated, or which needs to be generated, will be reduced. On the other hand, if more lateral relations have been created, there would be an increase in the level of activity, therefore reflecting an increase in information processing capacity.

The second dimension of uncertainty, information processing capacity, is measured by the same three intervening variables. When the before and after measures of the three intervening variables are compared, any decrease reflects the decrease in information processing requirement, and any increase will reflect the increase in information processing capacity. This is because by comparing the measures from the same organization, the variable of information already possessed by the organization can be kept constant (e.g., by comparing the number of employees and the level of performance).

However, the effects of increasing the information processing capacity may be offset by the effects of decreasing the information processing requirement. For example, the number of versions of product/service generated may be increased, indicating an increase in information processing capacity. This increase may have occurred locally, on one system. As a result of that increase in information processing capacity, the number of inputs and the level of performance of the *whole* business process may be decreased. This overall decrease in the information processing requirements of the business process is consequently reflected in the dependent variables.

Alternatively, at another level, the creation of new self-contained tasks may be done at the same time as the creation of lateral relations. In such a case, the business process may need to be broken up into subprocesses to measure the separate effects of information processing capacity and information processing requirements. Consequently, the level of analysis of that particular case changes from a business process to a business subprocess. Using the subprocess as an alternative level of analysis will not contradict the purpose and method of measurement proposed by this research.

Case Study Propositions

Yin (1989) and Eisenhardt (1989) propose several steps for building theories from case studies. Yin (1989) argues that individual case studies in multiple-case-study research should be considered as multiple experiments. Yin (1989) proposes the use of analytical generalization rather than statistical generalization, which is commonly found in surveys using a sample of data from a population. In statistical generalization, an inference is made about the population by testing a hypothesis or series of hypotheses on empirical data collected. In analytical generalization, a previously developed theory is used as a template with which to compare empirical data collected from a case study (Yin 1989). If two or more cases are shown to support the same theory, Yin (1989) argues that replication may be claimed. The evidence for the theory is made stronger if two or more cases support that theory, but do not support an equally plausible rival theory (Yin 1989). Of course, the evidence for the theory should be accepted only if the research can

demonstrate construct validity, internal validity, external validity, and reliability (Kidder and Judd 1986).

The following general propositions were developed using the framework in figure 6 and, the variables and measures in table 1:

1. Implementation of workstation-based client/server systems in a business process facilitates the compression of steps sequentially across functions by reducing the information processing requirement for that business process.
2. Implementation of workstation-based client/server systems in a business process facilitates the compression of steps vertically in the managerial hierarchy by reducing the information processing requirement for that business process.
3. Implementation of workstation-based client/server systems in a business process facilitates the reduction of slack resources by reducing the information processing requirement for that business process.
4. Implementation of workstation-based client/server systems in a business process facilitates the reduction of distance between the point of decision and the source of information (and the elimination of intermediaries) by reducing the information processing requirement for that business process.
5. Implementation of workstation-based client/server systems in a business process facilitates the creation of parallel processes from sequential processes by increasing the information processing capacity for that business process.

6. Implementation of workstation-based client/server systems in a business process facilitates the creation of linkages between parallel activities during the process by increasing the information processing capacity for that business process.

The variables that measure successful business process change are also shown in table 1. Compression of sequential tasks is measured by the change in the number of employees involved in the sequential tasks across functions. Compression of tasks vertically up the managerial hierarchy is measured by the change in the number of employees involved in the business process within the managerial hierarchy. If there is more than one vertical hierarchy involved in the business process, the number of employees in all vertical hierarchies will be included.

The third dependent variable, reduction in slack resources, is measured by the change in the amount of slack that is reduced as a result of the implementation of the client/server system. The change in the amount of slack is measured in quantitative terms (e.g., number of days, number of inventory items, number of suppliers). The fourth variable, reduction of distance between the source of information and the point of decision, is measured using the reachability index between the source of information and the point of decision. The source of information is commonly the person who is in direct contact with the customer. The point of decision is defined as the person in the business process who makes the final decision in regard to the completion of that business process. The reachability index is a network analysis metric that measures the path distance between actors in the network. Reachability is calculated by multiplying the matrix of relations by itself T times. The resulting K^T elements give the number of T-step

connections leading from actor i to actor j. The reachability matrix, R^T, the sum of the K^T matrices, shows whether or not actor i can reach actor j in T or fewer steps.

$$R^T = K + K^2 + K^3 + ... + K^T$$

The fifth variable, creation of parallel processes from sequential processes, is measured by counting the number of concurrent activities created as a result of reconfiguring sequential processes. These concurrent activities would not have existed without the implementation of the client/server system. Creation of linkages between parallel activities during a process is measured by counting the number of direct linkages between concurrent activities that take place during (not at the end) of the business process.

Nine operational propositions were developed to systematically compare the research framework with the evidence collected. The idea is to move iteratively toward a theory that closely fits the data (Eisenhardt 1989). The nine propositions were produced from six general propositions introduced earlier, because of the assumed presence of the intervening variable. As explained by Baron and Kenny (1986), a variable functions as a mediator or intervening variable when: (1) variation in levels of the independent variable significantly account for variations in the presumed mediator, (2) variations in the mediator significantly account for variations in the dependent variable, and (3) a previously significant relation between dependent and independent variable is no longer significant when the mediator is absent. Hence, three more propositions have been added to test the first criterion before the second criterion can be tested. The third qualification for the intervening variable was not tested in this research.

For each site in this multiple case study, the following operational propositions were investigated:

P-1: The use of workstation-based client/server systems changes the frequency of asymmetric direct contacts between individuals in the business process.

P-2: The use of workstation-based client/server systems changes the number of versions of products/services generated by the business process.

P-3: The use of workstation-based client/server systems changes the level of activity generated by the individuals involved in the business process.

P-4: The number of employees involved in the sequential tasks across functions decreases as a result of a decrease in information processing requirements.

P-5: The number of employees involved vertically up the managerial hierarchy decreases as a result of a decrease in information processing requirements.

P-6: The reachability index between the source of information and the point of decision decreases as a result of a decrease in information processing requirement.

P-7: The amount of slack decreases as a result of a decrease in information processing requirement.

P-8: The number of concurrent tasks increases as a result of an increase in information processing capacity.

P-9: The number of direct linkages between concurrent tasks increases as a result of an increase in information processing capacity.

The proposition that using client/server systems reduces information processing requirement or increases information processing capacity is investigated using three propositions: P-1, P-2, and P-3. Different measures are used in these three propositions in order to maximize construct validity. If these propositions are shown to occur, the research evidence would fit the proposition that the use of client/server systems is related to changes in information processing requirement or capacity. If P-1, P-2, and P-3

propositions occur, the study can proceed with testing propositions P-4 through P-9. If propositions P-4 through P-7 occur, the research evidence will suggest that reduction in the information processing requirement fits with at least one of the variables representing BPR. The proposition that relates the increase in information processing capacity to changes in business processes is investigated using propositions P-8 and P-9. If P-8 and P-9 show positive results, the research will have shown that increase in information processing capacity fits with at least one of the variables representing BPR.

The accuracy of this study's findings depends on the richness of the framework and on the validity and reliability of the measures used in the study. This chapter has explained the framework on which the study is based. The next chapter discusses the research methodology, and the validity and reliability of the measures.

CHAPTER 3: LIST OF REFERENCES

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CHAPTER 4

RESEARCH METHODOLOGY

The purpose of this chapter is to explain the research methodology chosen by the study. The research methodology needs to fit the objective of this study, which is to describe the role of client/server systems in changing business processes. In fulfilling this objective, the research design needs to accommodate several assumptions.

Client/server technology is in its formative stages (Kappelman and Guynes 1995). Therefore, varying user experiences, the many different contexts of implementation, and trial-and-error-type problems can confound any client/server study. For these reasons, exploratory case study research appears to be a suitable methodology for researching the role that client/servers play in changing business processes (Benbasat, Goldstein, and Mead 1987). This is because case studies are able to capture the rich knowledge and different practices of the users, and enable researchers to develop theories and prescribe management guidelines (Yin 1989).

Although client/server technology is new, previous research on the subject of I/T impacts on organizations is available. In addition, previous information system studies (Sviokla 1989; Goodhue and Thompson 1995) have used the information processing paradigm. This research should be able to build upon already developed hypotheses from previous research studies and generate theory. Therefore, the emphasis of this study

should be on "how" client/servers facilitate business process change in some cases and "how not" in others (Benbasat, Goldstein, and Mead 1987).

Based on these arguments, this research chose to employ a combination holistic multiple-case-study design (Yin 1989), using a one-group, pretest-posttest approach borrowed from traditional experimental design (Campbell and Stanley 1963; Cook and Campbell 1979). By employing a multiple-case-study design, the research was able to examine client/server systems in its natural settings and make comparisons. Additionally, multiple cases increase the external validity of the research (Yin 1989; Eisenhardt 1989). The range of variables observed and the scope of the case study are delineated using the research framework in figure 6. The research design proposed is depicted in figure 10 (Campbell and Stanley 1963; Cook and Campbell 1979).

$O_1 \quad X \quad O_2$

Fig. 10. Research design

Pretest scores are measures taken before the implementation of the client/server system. Posttest scores are measures taken after the implementation of the client/server system. O_1 are pretest scores for the organization using client/server systems, X is the implementation of client/server systems (the treatment), and O_2 are posttest scores for the same organization using client/server systems.

Level of Analysis

Network analysis techniques allowed this case study to be examined at both a macro and micro level of analysis (Knoke and Kuklinski 1982). However, in this study, the macro level of analysis -- the business process level -- was predominantly used.

Table 2. -- Levels of analysis in the study

Levels of Analysis	
Individual (Micro)	Business Process (Macro)
	Output diversity as measured by the change in the number of versions of product/service
	Number of inputs measured by the change in the frequency of asymmetric direct contacts
	Level of performance measured by the change in the level of activity generated
	Compression of sequential tasks measured by the change in the number of employees in sequential tasks
	Compression of vertical tasks as measured by the change in the number of employees vertically in the managerial hierarchy
	Reduction of slack in terms of slack resources in business process
Reduction in the distance between the source of information and the point of decision as measured by the change in the reachability index	
	Creation of parallel processes from sequential processes to operate in parallel as measured by the change in the number of concurrent activities within the business process
	Creation of new linkages of parallel activities as measured by change in the number of direct links between concurrent activities

The one single measure that was used at the micro level was the distance between the customer and the decision maker. This dual-level-analysis approach illustrates the flexibility of this study's research design and the power of network analysis in information systems research. Table 2 shows the two levels of analysis used in this study -- individual and business process -- and their associated measures.

Yin's (1989) interpretation of using different levels of analysis takes the form of two research designs -- the holistic and embedded case study design. A holistic design examines an organization at a global level. For example, a holistic case study design might look at the centralization and decentralization of decision authority. An embedded case study design examines outcomes from individual projects within that organization, or the outcome associated with an individual in that organization. In this study, most of the measures used are at the global business process level.

Retrospective Studies

One of the strengths of this study lies in the power of the measures used. The set of measures used in this study allows for structured interviewing, as well as the use of retrospective methods for pretest scores. The questionnaire items that were used for structured interviewing require that subjects only respond with average values. This feature enabled the interviewees to respond easily in a short period of time. Also, the researcher could collect from as many subjects as possible to verify the accuracy of the data collected. Pretest measures can then be collected retrospectively even *after* implementation of the client/server system, as long as the time of implementation did not

take place too far in the past. To illustrate the feasibility of this approach, pretest data were collected retrospectively for one of the sites in the case study.

Site Selection

Sites for the case studies were chosen such that various levels of database scope and the moderating variable were represented in the study. No consideration was given to any particular industry, product, or service. Most organizations that were approached were unwilling to share the details of their business processes, thereby limiting the choices available for data collection. Also, many organizations that had plans to implement client/server systems could not determine the expected implementation date for their systems.

A preliminary mail and fax survey was performed to collect information about organizations that fit the description required by this research, and to solicit companies interested in the research. The requirement for the research was that the company should be in the process of reengineering their systems and implementing a client/server system in the next one to four months. This strategy was undertaken to control for rival hypotheses that might affect the results, if the period between pre-implementation and post-implementation data collection became too long. The company should also be able to share the details of their business processes and allow the researcher to examine any archival data that might support the study. Although over 30 major companies in the Dallas/Fort Worth metropolitan area were approached over a period of two months, only a few responded. The preliminary mail and fax survey identified organizations that were

undergoing organizational redesign or BPR, and were implementing or not implementing client/server systems. As a result of this mail and fax survey, four organizations that fit the requirements agreed to participate in this study.

Collection of Evidence

The evidence for this study came from three sources: (1) interviews, (2) direct observation, and (3) physical artifacts. The interviews conducted were a combination of structured and focused interviews performed on site. A pilot test for the research instruments was conducted at a major consulting organization three months before actual data collection began. Changes and improvements were included as a result of that pilot test. Three instruments were developed for the structured interviews. The first instrument (form A in appendix C) collected demographics, identified organizations that were or were not implementing client/server systems, and verified the data collected by the other two instruments. Form A also collected other information that was not directly related to this research but was otherwise useful. Please refer to form A's cover page for further information.

The second instrument (form B -- employee questionnaire) was administered twice for each organization that participated. Form B was administered once before the implementation of client/server systems, and once more at least a month after the implementation of client/server systems. The post-implementation data collection was performed at least a month after the implementation, so that the users had overcome the learning curve of using the new client/server system, and were receiving the expected

benefits. Form B was administered to all employees involved in the business process (including the managers), regardless of their position in the organization. The objective of form B was to collect the data necessary to build the business process network diagram, and to identify potential rival hypotheses that could present a threat to the validity of this study. Form B has two parts, part A and part B. Part A was filled out before the implementation, and part B was filled out after the implementation of client/server systems.

The third instrument (form C -- manager's structured interview) was also administered twice, before and after the implementation, but only to the managers responsible for at least a major portion of the business process. This instrument is a structured interview with the managers. It was used to define the boundaries of the business process, describe the inputs and outputs of the business process, and to collect other variables as defined in the list of dependent variables. The final item in part B of form C (item 7) was used to validate the level of acquiescence of the manager's response. As the subjects in the research were comfortable with the researcher's taping the interview sessions, both interviews with managers and employees were tape-recorded and transcribed. The instruments and an explanation of the items used are given in appendix C.

During the structured interviews, subjects involved in the research were asked open-ended questions designed to uncover details of the business process. Several of the open-ended questions include "describe the business process as best you can," and "which

parts of the business process do you think need improvement." A major portion of the focused interview was used to corroborate other subjects' versions of what was taking place within the business process.

Direct observation was used to corroborate the evidence collected using the interviews, and to collect evidence of rival hypotheses. Possible rival hypotheses that were observed are listed in the next section. Physical artifacts in the form of computer reports, computer printouts, data entry forms, and new computer equipment were observed as part of field visits to the case study site.

Validity and Reliability Issues

This study is designed to maximize validity and reliability. Validity and reliability issues in case study research are discussed in Yin (1989) and Eisenhardt (1989), and are applied in this study. Construct validity is the extent to which the variables measured in the study represent the concepts that are being studied. Internal validity, in the case of causal studies, is the extent that the research design permits the researcher to reach causal conclusions about the effects of the independent variable on the dependent variable. External validity establishes the domain in which a study's findings can be generalized. Reliability is the extent to which the operations of the study can be repeated with the same results.

Construct Validity

Multiple sources of evidence were used to maximize construct validity. For example, responses to Form A and direct observation were used to identify managerial action as the independent variable in the study. Direct observation, existence of physical artifacts, and centrality were used to identify the moderating variable -- client/server system use. Three variables were used to measure uncertainty: (1) output diversity, (2) number of inputs, and (3) level of performance. The dependent variable, business process change, was measured using six different measures, all of which were explained in chapter 3. Each dependent variable was measured not only by structured interviews, but also by using direct observation of behavior and by noting the presence of physical artifacts.

The second strategy employed to increase construct validity was to ask the subjects involved in the interviews to review the draft of the case study report (Yin 1989). After each interview, a brief analysis of the data was performed. Then a narrative, together with the analyzed data, was faxed to key informants at the organization for review. The key informants were contacted and asked if there were any discrepancies in the data collected.

The third strategy employed to increase construct validity was the establishment of a chain for evidence (Yin 1989). For each variable measured in the study, a date on which the variable was measured was recorded. Also, a reference was made to the source of the data; whether it was an instrument used, a tape that was recorded, or a report that was written.

Internal Validity

As discussed by Campbell and Stanley (1963), the one-group, pretest-posttest design poses many internal validity problems, in particular relating to (1) history, (2) maturation, (3) testing, (4) instrumentation, and (5) statistical regression. The following paragraphs discuss these rival hypotheses in detail and how they were controlled in the study.

History

History refers to other change-producing events that may have occurred in addition to treatment X (figure 10). To minimize this threat, the time elapsed between pre-implementation data collection and post-implementation data collection was limited to five months. The following items are plausible rival explanations for business process change; they were recorded using form B (employee questionnaire):

a) a major change in primary tasks

b) a change in the pay system

c) promotions

d) training programs

e) involvement in a human resource intervention program (teamwork, job enrichment programs, or quality circles)

f) transfers

g) a change in the structure of the department or the organization

h) a change of supervision or superiors

i) any other major changes noted by the employee.

The following rival explanations were observed and recorded, but not included in the questionnaires:

a) changes in the operating system, computers, or any hardware and software not related to the client/server implemented

b) changes in the degree of formalization of the organizational structure

These observations helped control for moderating variables that may have caused a change in the dependent variable.

Maturation

Maturation threats occur when other processes exist and continue to operate, even if no treatment X had been introduced (e.g., biological and psychological processes). These processes could affect the results observed at O_2 (Figure 10). Growth-type maturation threats were not major threats in this study because the time between pre- and post-implementation data collection was limited to five months. The variable that was noted in relation to this threat was the willingness or resistance of the people to use the new system.

Testing

Testing refers to the effect that the treatment itself might have on the subjects. A typical example of this threat is acquiescence when the manager of a business process is

asked about certain items concerning the success of the redesign effort. Acquiescence was minimized by using quantitative measures for variables (Eisenhardt 1989). Also, an item was included in the posttest manager's questionnaire (form C) asking the manager about the success of the redesign efforts. This item can be used in a statistical test if the sample size is sufficient.

Instrumentation

Instrumentation concerns changes to the measurement procedures, performed either purposely or inadvertently as a result of the subjects' becoming more experienced with the instruments. In this study, instrumentation was not a major threat, as observations were made only on two occasions, once before the treatment, and again after the treatment, and the same instrument is used in both cases. The last threat, statistical regression, is not applicable in this study because no regression techniques were used to analyze the data collected.

External Validity

Because case studies rely on analytical generalization instead of statistical generalization, external validity is increased by performing a multiple case study as opposed to a single case study (Yin 1989). In statistical generalization, an inference is made about the population by testing a hypothesis or series of hypotheses on empirical data collected. In analytical generalization, a previously developed theory is used as a template with which to compare empirical data collected from a case study. If two or

more cases are shown to support the same theory, Yin (1989) argues that replication may be claimed. The evidence for the theory is made stronger if two or more cases support that theory but do not support an equally plausible rival theory.

Reliability

Two strategies were used to increase the reliability of this case study: (1) using a case study protocol, and (2) developing a case study database. Using these three strategies, other researchers can replicate the study and therefore increase its reliability (Yin 1989). A case study protocol contains the instruments used in the study and the procedures and general rules that were followed in using the instruments. By developing a case study protocol, other investigators can replicate the study and therefore increase the study's reliability. The following paragraphs list the steps that were taken to conduct the study:

Case Study Protocol

A. Purpose

The purpose of the case study is to describe the role of client/server systems in changing business processes. The case study can be executed by a single researcher. However, if many sites are involved, it may be advantageous to involve more than one researcher to perform the data collection. The overview of the case study is in chapter 1. The theoretical basis for the case study is discussed in chapter 3.

B. Procedures

1. Initial scheduling of field visit

The researcher should schedule an appointment with someone representing the top management of the organization to explain the merits of the case study. The researcher should perform the following steps during that meeting:

a) Explain to top management the benefits the case study will bring to the organization. Several of these benefits include:

   i) a detailed analysis of their process reengineering effort

   ii) highlighting of weaknesses and strengths of the business process design

   iii) suggested improvements to the business reengineering process.

b) The researcher should try to get as much support as possible from top management for the research.

c) Discuss with top management which business process to study, what products or services are generated, and who are the customers of that business process.

d) Determine the implementation or rollout date of the new client/server system and add at least three to five months' possible delay to the expected implementation date.

e) Determine the key informants who will be interviewed by the researcher and how much time it will take to perform the interviews. If the business process involves many departments and many employees, the researcher

will need to consider the amount of time necessary to devote to that business process. The overriding consideration in determining how many key informants to interview is the need to collect as much data as necessary that will describe in sufficient detail the variables delineated by the research framework. The researcher should be able to schedule appointments with key informants at their convenience.

f) Show top management the instruments that will be used and request that they send copies of an introduction letter, an overview of the case study and its objectives, forms B and C, and a note explaining their rights as research subjects in a study, to the key informants at the sites where the case study will be performed. This packet of information will prepare the site for the visit by the researcher.

g) Request that top management fill out form A.

2. Pretest data collection

a) Visit with each key informant and explain briefly the objective of the study and how it will be conducted. Make sure the key informant is comfortable with tape recording the interview.

b) Administer part A of form B to selected employees involved in the business process and part A of form C to the manager (or managers) responsible for at least a major portion of the business process. The instruments and the

underlying objectives of each item in the research instruments are explained in appendix C.

c) Make note of possible rival explanations that might affect the dependent variable.

3. Ask the key informant open-ended questions concerning the details of the business process. The researcher should be able to write down the steps involved in completing the business process, and how much time and effort is spent in each step.

4. Posttest data collection

a) Repeat the protocols in step 2. The researcher should use part B of form B and C for the posttest data collection.

5. Data Analysis Methods

a) Data analysis methods are discussed in detail in the next section.

Case Study Database

The second strategy used to increase reliability is to develop a case study database. The database for this case study consists of tapes from interviews, transcription of those tapes, notes made from direct observation, filled-out interview forms, tables in the form of Microsoft Excel spreadsheets of measures, and written reports of the researcher. This database is available for other investigators to review and compare.

Data Analysis Methods

This section discusses the data analysis methods used in this study. Network analysis techniques such as network diagram, relationship matrices, and task tables were used to generate the metrics for each variable in the study (Knoke and Kuklinski 1982). For each individual case study, a detailed analysis using pattern-matching logic and explanation building was performed. A cross-case analysis of the data was also performed to compare and triangulate the results collected (Yin 1989; Eisenhardt 1989).

The following steps were used to analyze the data collected from each site. The first step was to draw a network diagram of the business process before and after the implementation of the client/server system. An example of a network diagram is shown in figure 11.

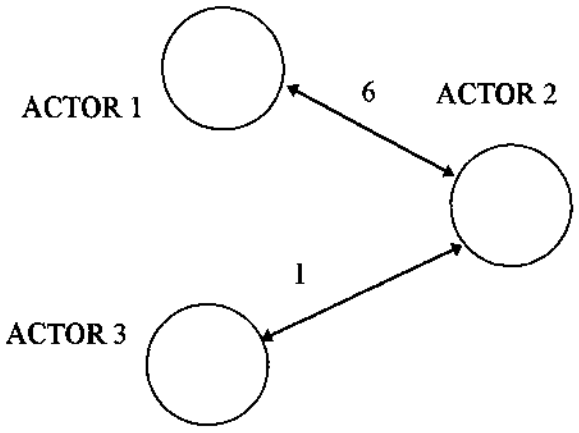

Fig. 11. Example of a network diagram

Network Analysis

The network diagram shows actors in the network connected by arrowed lines. An actor in a network diagram is defined as an individual, or a group of individuals involved in the relation. Since the focus of the analysis is the relationship between actors, the client/server system is not drawn into the network diagram. Each actor is represented by circles in the network diagram. Arrowed lines connecting the circles show communication between the actors in order to complete the tasks associated with the business process. Each line is captioned with a number that reflects the frequency (per week), on average, that such communication or consultation takes place. The network diagram allows the researcher to grasp the magnitude and extent of the business process, as well as to recognize any patterns that might exist. With the help of the network diagram, and other data collected from the research instruments, relationship matrices and task tables are generated.

The network diagram helps the researcher to calculate:

1. the number of employees sequentially across functions
2. the number of employees vertically in the managerial hierarchy
3. the total number of direct asymmetric contacts for the whole business process
4. the number of concurrent tasks operating in the business process
5. the number of linkages between concurrent tasks.

Table 3. -- Example of a relationship matrix

	First actor	Second actor	Third actor	CSS	Degree of actor	Sum of frequencies
First actor	0	15	6	1	3	21
Second actor	15	0	15	5	3	30
Third actor	6	15	0	3	3	21
CSS	1	5	3	0	3	9
Degree of actor	3	3	3	3	12	
Sum of Freq.	21	30	21	9		81

Relationship Matrix

Relationship matrices and task tables extend the analysis offered by the network diagram. An example of a relationship matrix is shown in table 3. In a relationship matrix, the actors arrayed in the matrix rows are initiators of the specified relation, and the actors arrayed in the matrix columns are recipients of the relation This study assumes reciprocated relations; thus, the element in row i and column j of a relationship matrix is identical to the element in row j column i, and the matrix is said to be symmetric. Each element z_{ij} in the matrix is equal to the strength of the relation between pairs of actors. The client/server system (CSS) is included in the relationship matrix in order to calculate its centrality, or level of involvement in the network.

The relationship matrix enables the researcher to calculate the degree of an actor in the network, and the sum of frequencies for each actor. The degree of an actor shows how many other actors have direct contact with the actor. It is calculated using the formula:

$$\text{Degree of } z_i = \sum_{i=1}^{N} y_{ijk}$$

where:

y_{ijk} represents the binary value (not the strength) of a relation from the *i*th actor directed to the *j*th actor in the *k*th network. A binary value means that a "1" represents an occurrence of a tie between two actors, and a "0" represents an absence of such a tie.
N is the number of actors in the network.

In table 3, the degree of each actor is 3, which means that each actor is directly in contact with each of the other 3 actors. In a social relation, the degree of an actor might represent that actor's popularity, influence, or power. In the context of this study, the degree of an actor represents the extent of involvement of an actor in the business process and is used, in matrix format, to calculate the centrality of the client/server system.

The sum of frequencies for each actor represents the sum of the frequency of contacts between two actors. The sum of frequencies represents the strength of the communication relation between two actors and is calculated using:

Sum of frequencies of $z_i = \sum_{j=1}^{N} z_{ijk}$

where:

z_{ijk} represents the frequency of contact from the *i*th actor directed to the *j*th actor in the *k*th network. Frequency of contact is defined as the number of times an actor is consulted per period in order to complete the business process.
N is the number of actors in the network.

Half of the total sum of frequencies for the business process is equal to the total frequency of asymmetric direct contacts. In the context of this study, the total frequency of asymmetric direct contacts represent the number of inputs of the business process (Table 3).

Reachability Matrix

A derivative of the relationship matrix is the reachability matrix. The reachability matrix contains the path distances between actors in a network. This helps the study calculate the distance between the source of information and the point of decision. The source of information is commonly the external customer of the business process. The point of decision is defined as the person in the business process who makes the final decision in regard to the completion of that business process. Reachability matrices are calculated by multiplying the relationship matrix that contains binary figures (0's and 1's) by itself T times. The resulting K^T elements give the number of T-step connections leading from actor i to actor j. The reachability matrix, R^T, the sum of the K^T matrices, shows whether or not actor i can reach actor j in T or fewer steps.

$R^T = K + K^2 + K^3 + ... + K^T.$

Task Table

A task table shows a breakdown of all possible tasks that make up the business process, regardless of whether the task is necessary for any instance of a business process. The first column defines the person or group performing the tasks; the second column describes briefly the task; the third column, the time taken for that individual to do the tasks; and the fourth column, any slack time or slack resources associated with that task. The total of the third column equals the average time it takes to complete the business process, assuming that all possible tasks were performed. This total time is used as the

measure for the level of performance required for that business process. The total of the fourth column equals the slack resources used in the business process. Typically, this measure is also in terms of time (days or hours). All the data analyzed from the network diagram, the relationship matrix, the reachability matrix, and the task table are summarized in a summary table for each research site.

All these techniques are used to generate a summary of evidence from each case study. Using another technique called pattern-matching logic (Yin 1989), the collected evidence are further analyzed.

Pattern-Matching Logic

In cases when a small sample size excludes traditional inferencing theory and statistical methods, pattern matching provides a means of linking the evidence collected to the propositions of the case study. Pattern matching is based on Campbell's (1975) work whereby several pieces of information from the same case may be related to a theoretical proposition.

Pattern-matching logic involves comparing an empirically based pattern with a predicted one. If the patterns coincide, the results help a case study strengthen its internal validity (Yin 1989). In this study, the research framework provides a set of nonequivalent dependent-variables pattern and rival explanations. The set of nine propositions specified in chapter 3 were assessed using different measures. If the results were as predicted, the case study is able to draw solid conclusions about the effects of the moderating variable, based on the pattern demonstrated by the three intervening and six dependent variables.

The results from the first case study can be strengthened by other case studies, in which other client/server systems are implemented.

As Yin (1989) carefully notes, pattern matching is incapable of making any precise comparisons. Therefore this research emphasizes only the direction of change of the variables in the research framework, rather than their magnitudes. As Yin (1989) states, the comparison between the predicted and the actual pattern may involve no quantitative or statistical criteria. However, in this research, quantitative measures are used as an extension to investigate the utility of new measures of client/server presence in a business process.

Pattern-matching logic is generally used to strengthen the internal validity of a single-case study (Yin 1989). In order to strengthen the external validity of the case study research, another technique called explanation building is employed.

Explanation Building

The essence of explanation building is the iterative process of generating other plausible, or rival explanations by refining the set of ideas and results collected in each case study. In this sense, explanation building is feasible only in a multiple-case-study situation. The process of explanation building begins with an explanation that is assumed incomplete in the beginning, and then its theoretical position is revised continually to a point that the cumulative evidence from several case studies ultimately suggests a final explanation. Both pattern matching and explanation building were used to analyze the data collected from the case studies.

CHAPTER 4: LIST OF REFERENCES

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CHAPTER 5

RESEARCH RESULTS AND DATA ANALYSIS

Five different business processes from four organizations were studied and analyzed. Pre-implementation data were collected one to four months before the expected implementation date. Post-implementation data collection was performed at least one month after the scheduled implementation date. Unfortunately, two of the businesses postponed the implementation date of their client/server systems. As a result, the post-implementation data could not be collected within the five-month limit defined by the research design. The post-implementation data collection for these two business processes was abandoned.

A retrospective data collection method was performed on one of the remaining three business processes to show that retrospective data collection methods are feasible using the study's research design. The data collection for the retrospective study was performed three months after the implementation of the client/server system.

First Business Process: Electric Co.

The first case study was a major electric utility company (referred to henceforth as Electric Co.). Annual sales of Electric Co. were over $1 billion in 1994. Between 250 and

500 people were employed at Electric Co. in 1994. In 1993, Electric Co. began a major business process reengineering effort. Many employees were transferred to different departments, and many more were discharged. Two business processes were analyzed at Electric Co.: (1) Electric Co.'s regional maintenance scheduling system, and (2) Electric Co.'s distribution information system (DIS). The implementation of Electric Co.'s DIS was postponed beyond the five-month limit required by the research design.

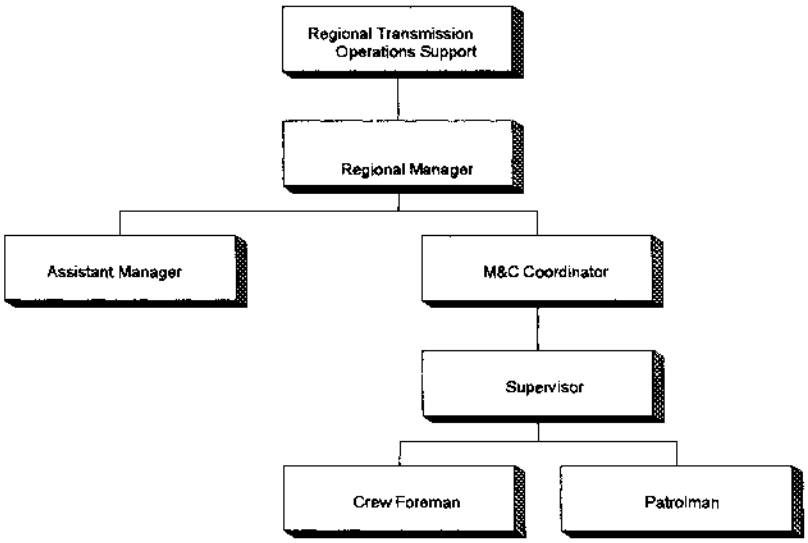

Fig 12. Electric Co.'s regional organization diagram

The Maintenance Scheduling System

Electric Co. had a division called transmission operations support that managed the transmission of electricity. This division was responsible for the maintenance of various equipment that carried electricity to customers (e.g., transformers and circuit breakers).

This maintenance function, performed at the regional level by regional transmission centers, involved periodic preventive maintenance, as well as repair of faulty equipment.

The diagram in figure 12 shows the organizational chart of one of Electric Co.'s regional transmission operations support organizations. The business process analyzed was the scheduling process of this maintenance function. The objective of maintenance scheduling was to schedule work orders for Electric Co.'s equipment. Each piece of equipment had a specific maintenance schedule.

Electric Co. had undergone a massive restructuring and reengineering process. One of the major reasons for this effort was recent cutbacks in the work force. At that time, there were not enough workers to perform the necessary maintenance and repair work on all the equipment. In order to maintain an acceptable standard of operations, a new schedule for equipment maintenance had to be developed.

The Business Process Before the Implementation

Traditionally, each crew foreman kept three or four books that contained information about substations and equipment they needed to maintain. Periodically, the foreman would write out a schedule and submit this proposed schedule to the supervisor. The supervisor in turn would consult with other supervisors, the chief supervisor, the clearance coordinator, and Electric Co.'s distribution center. This scheduling process took several days to complete. On Friday of each week, the schedule was finalized, and on Monday of the next week, the supervisor would hand out the final schedule to his crew foremen. The foremen would ask their crew to perform the work. After the work was

completed, the foremen would log the information either on cards or in files that were kept on each piece of equipment. Because this information was kept manually, there was no way of generating reports on any of the equipment. Besides the crew foremen, testers also periodically examined equipment and reported back to the supervisor if any of the equipment needed maintenance.

Description of the Client/Server System

The new client/server system was a FoxPro for DOS application that ran on a workstation on a Novell Netware local area network at a regional office. The FoxPro application was designed and programmed by the information systems department of Electric Co. The objective of the new client/server system was to document electronically the information that was kept on cards and in files, in order to track the activity of each piece of equipment. Using the collected history of maintenance and repair work, the application was designed to monitor the results of the maintenance performed on each piece of equipment, and change the maintenance schedule accordingly. The final aggregation of data was expected to generate new information that was not documented in any of the equipment manuals.

The information from the business process was entered using the keyboard, or was downloaded from hand-held computers. Once a month, the FoxPro application printed out a schedule of maintenance that was handed to the supervisor and the foremen. This schedule was used by the supervisor and the foremen to organize their maintenance plans. Using a set of equations involving time, events, and other parameters, a "critical number"

was generated for each piece of equipment. A large "critical number" identified equipment that was in need of maintenance.

Data Analysis

The business process analyzed is the maintenance scheduling process, not the maintenance function itself. This distinction is important, because the collected data relate to the scheduling function rather than the maintenance function. The foreman assigned for maintenance was the customer of this process. The product or service generated by this process was a schedule of maintenance for each piece of equipment. The network diagram for the process before and after the implementation of the client/server system (CSS) is shown in figures 13 and 14, respectively.

Tables 4 and 5 show the relationship matrices that correspond to the network diagrams in figures 13 and 14, respectively. Tables 6 and 7 show the reachability matrices R^2 for the relationship matrices in tables 4 and 5, respectively. R^2 corresponds to whether or not actor i can reach actor j in T or fewer steps. R^2 is calculated using the formula:

$$R^T = K + K^2 + K^3 + ... + K^T$$

where K^T is the relationship matrix multiplied by itself T number of times.

Table 8 shows the tasks that make up the business process before and after the implementation of the client/server application. The first column defines the person or group performing the tasks, the second column contains a brief description of the task, the third column contains the time taken for that individual to do the tasks, and the fourth

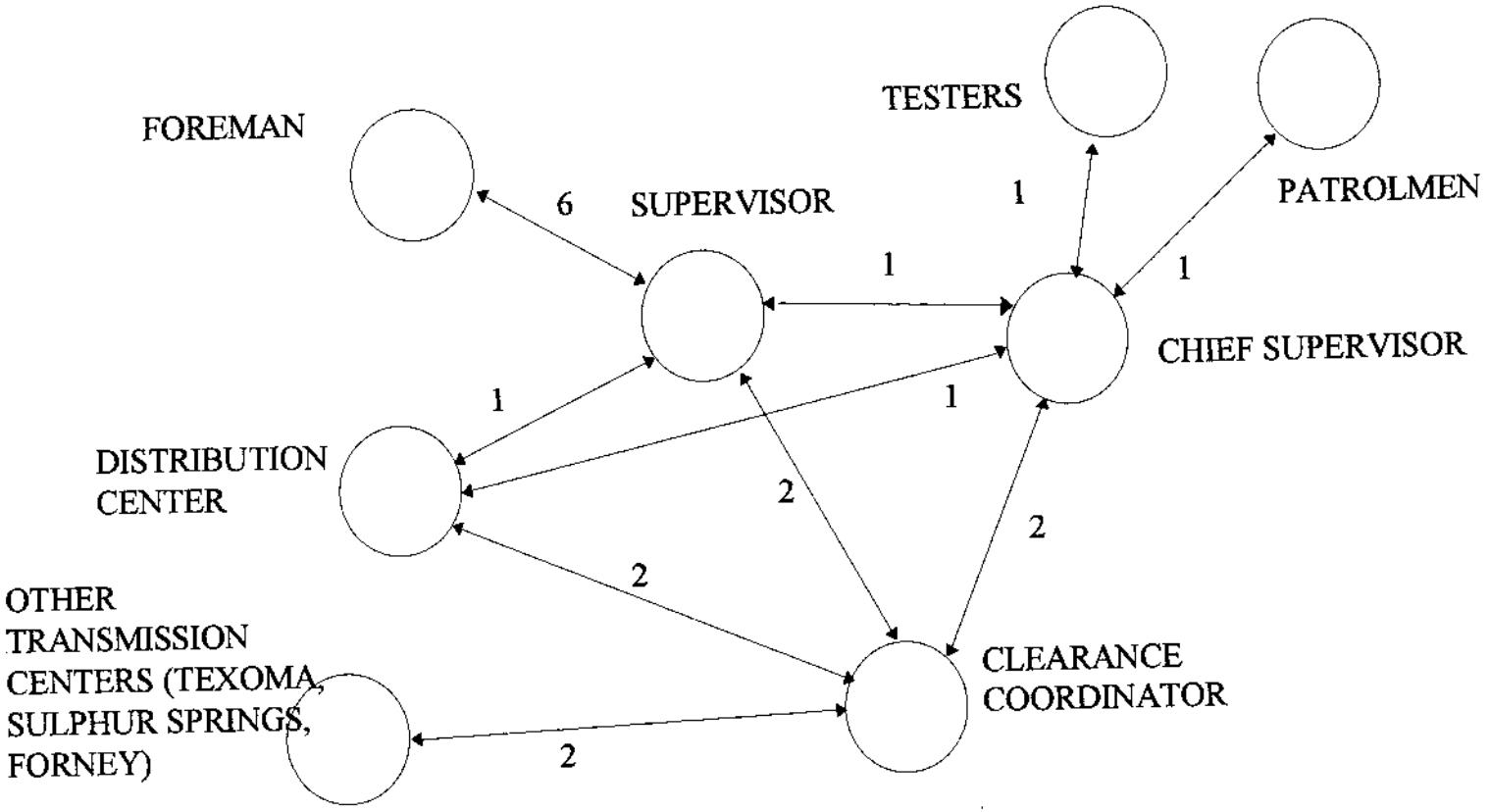

Fig. 13. Electric Co.'s business process network diagram before implementation

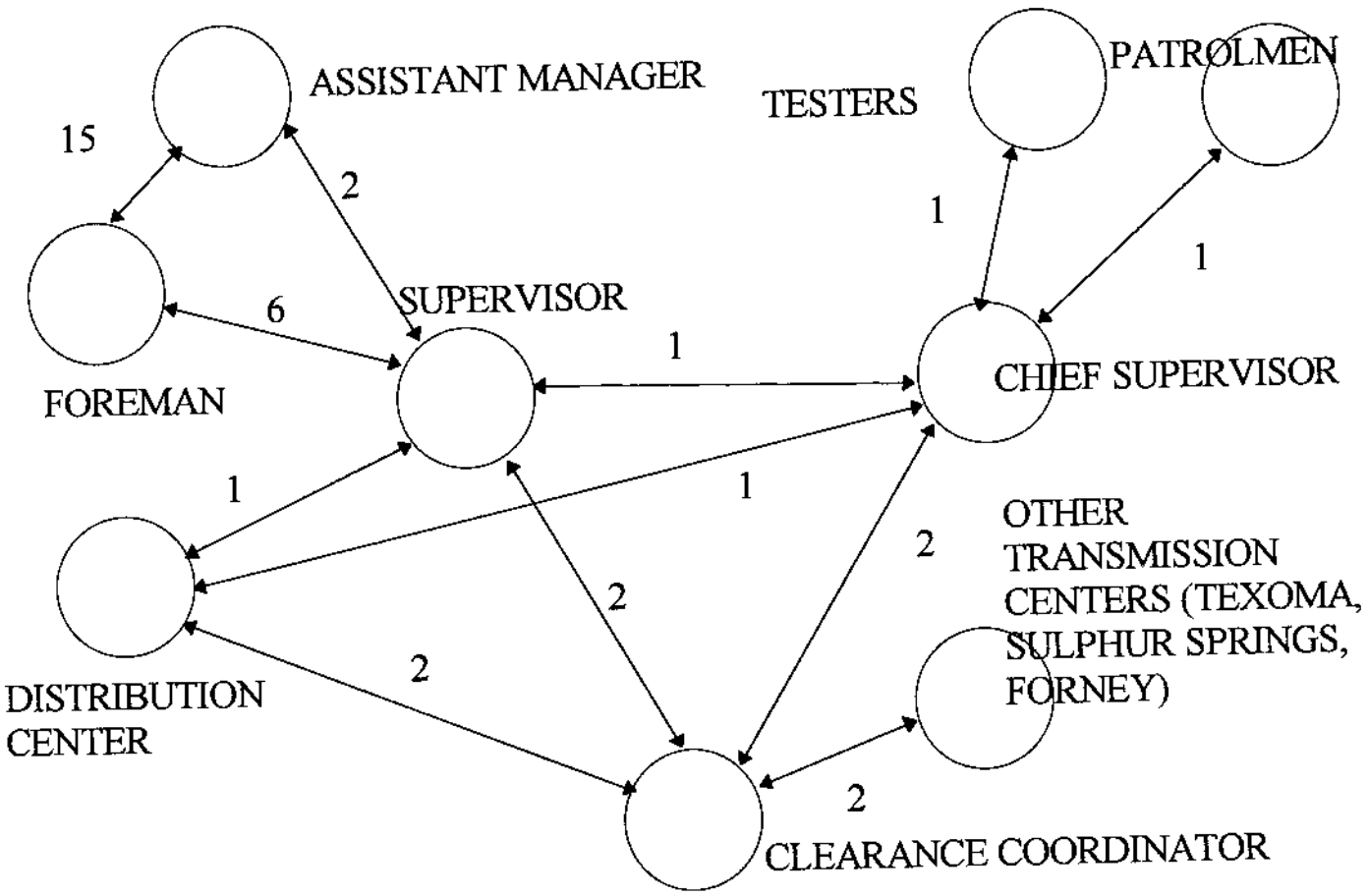

Fig. 14. Electric Co.'s business process network diagram after implementation

Table 4. -- Electric Co.'s relationship matrix before implementation

	Super-visor	Assist. manager	Fore-man	Testers	Patrol-men	Chief super-visor	Distri-bution	Clear-ance coordi-nator	Other trans-mission	CSS	Degree of actor	Sum of freque-ncies
Supervisor	0	N/A	6	0	0	1	1	2	0	0	4	10
Assist. manager	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Foreman	6	N/A	0	0	0	0	0	0	0	0	1	6
Testers	0	N/A	0	0	0	1	0	0	0	0	1	1
Patrolmen	0	N/A	0	0	0	1	0	0	0	0	1	1
Chief supervisor	1	N/A	0	1	1	0	1	2	0	0	5	6
Distribution	1	N/A	0	0	0	1	0	2	0	0	3	4
Clearance coordinator	2	N/A	0	0	0	2	2	0	2	0	4	8
Other trans-mission	0	N/A	0	0	0	0	0	2	0	0	1	2
CSS	0	N/A	0	0	0	0	0	0	0	0	0	0
Degree of actor	4	N/A	1	1	1	5	3	4	1	0	20	
Sum of freq.	10	N/A	6	1	1	6	4	8	2	0		38

Table 5. -- Electric Co.'s relationship matrix after implementation

	Super-visor	Assist. manager	Fore-man	Testers	Patrol-men	Chief super-visor	Distri-bution	Clear-ance coordi-nator	Other trans-mission	CSS	Degree of actor	Sum of frequen-cies
Supervisor	0	15	6	0	0	1	1	2	0	1	6	26
Assist. manager	15	0	15	0	0	0	0	0	0	5	3	35
Foreman	6	15	0	0	0	0	0	0	0	3	3	24
Testers	0	0	0	0	0	1	0	0	0	2	2	3
Patrolmen	0	0	0	0	0	1	0	0	0	3	2	4
Chief supervisor	1	0	0	1	1	0	1	2	0	0	5	6
Distribution	1	0	0	0	0	1	0	2	0	0	3	4
Clearance coordinator	2	0	0	0	0	2	2	0	2	0	4	8
Other transmission	0	0	0	0	0	0	0	2	0	0	1	2
CSS	1	5	3	2	3	0	0	0	0	0	5	14
Degree of actor	6	3	3	2	2	5	3	4	1	5	34	
Sum of frequencies	26	35	24	3	4	6	4	8	2	14		126

Table 6. -- Electric Co.'s reachability matrix R^2 before implementation

	Super-visor	Assist. Manager	Fore-man	Testers	Patrol-men	Chief Supervisor	Distri-bution	Clearance Coordinator	Other Transmission
Supervisor	4	N/A	1	1	1	3	3	3	1
Assist. Manager	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Foreman	1	N/A	1	0	0	1	1	1	0
Testers	1	N/A	0	1	1	1	1	1	0
Patrolmen	1	N/A	0	1	1	1	1	1	0
Chief Supervisor	3	N/A	1	1	1	5	3	3	1
Distribution	3	N/A	1	1	1	3	3	3	1
Clearance Coordinator	3	N/A	1	1	1	3	3	4	1
Other Transmission	1	N/A	0	0	0	1	1	1	1

Table 7. -- Electric Co.'s reachability matrix R^2 after implementation

	Super-visor	Assist. Manager	Fore-man	Testers	Patrol-men	Chief Supervisor	Distri-bution	Clearance Coordinator	Other Transmission
Supervisor	5	2	2	1	1	3	3	3	1
Assist. Manager	2	2	2	0	0	1	1	1	0
Foreman	2	2	2	0	0	1	1	1	0
Testers	1	0	0	1	1	1	1	1	0
Patrolmen	1	0	0	1	1	1	1	1	0
Chief Supervisor	3	1	1	1	1	5	3	3	1
Distribution	3	1	1	1	1	3	3	3	1
Clearance Coordinator	3	1	1	1	1	3	3	4	1
Other Transmission	1	0	0	0	0	1	1	1	1

Table 8. -- Task table for Electric Co.'s business process

Person(s) performing task	Brief description of tasks	Time before CSS (min.)	Slack before CSS	Time after CSS (min.)	Slack after CSS
Assistant Manager	Generates monthly schedule	N/A		300	
Foreman	Lists required work for supervisor	15		N/A	
Supervisor	Enters foremen's lists and other required maintenance work into spreadsheet	60		60	
Supervisors	Coordinate work load among themselves	30		30	
Other transmission centers	Inform clearance coordinator of their schedules	10		10	
Clearance coordinator	Meeting to coordinate next week's schedule with chief supervisor, other supervisors, and distribution	120		120	
Clearance coordinator	Enters schedules into mainframe	60	2 days	60	2 days
Supervisors	Change individual schedule to reflect changes made during meeting	15		15	
Chief supervisor	Finalizes next week's schedule via e-mail	30		30	
Foreman	Receives final schedule and performs work	variable		variable	
Foreman Supervisor	Consults in case of problems	variable		variable	
Assistant manager	Enters finished work into application	N/A		10	
Foreman	Updates books to reflect work done	10		10	
	Total time taken	350		645	2 days

Table 9. -- Electric Co.'s summary of evidence

Variables	Measures			
	Pretest	Posttest	Difference	
Centrality of CSS	0	0.29	0.29	
Frequency of mutual direct contacts.....	19	56	37	Positive or negative difference indicates change in uncertainty
Number of versions	1	1	0	
Level of activity (time taken)...	350 min. (5 hr. 50 min.)	645 min. (10 hr. 45 min.)	295 min.	
Number of employees in sequential tasks	5	6	1	Negative difference indicates change from a reduction in information processing requirements
Number of employees vertically	4	5	1	
Reachability index between customer and point of decision	1 in two steps	1 in two steps	0	
Amount of slack in finalizing schedule	2 days	2 days	0	
Number of concurrent tasks.....	0	0	0	Positive difference indicates change from an increase in information processing capacity
Number of direct linkages between concurrent tasks.....	0	0	0	

column contains any slack time, for each task before the implementation. The fifth and the sixth columns contain the time taken, and slack time, for each task after the implementation of the client/server system. Table 9 shows the summary of the evidence collected. This table is developed using the information from the network diagrams, the relationship matrices, the reachability matrices, and the task table.

Changes in the Level of Uncertainty

Propositions P-1, P2, and P3 test for changes in the level of uncertainty experienced by the business process. If the frequency of mutual contacts, the number of versions of products or services, or the time taken to complete the business process changes after the implementation of the client/server system, the research framework suggests that the business process has experienced a change in the level of uncertainty.

Frequency of mutual direct contacts (P-1)

The increase in the frequency of mutual direct contacts from 19 to 56 times a week shows that the business process experienced a change in the level of uncertainty. No significant change had occurred to the amount of information processed by the business process in the period that the client/server system was implemented. Therefore, the increase in the frequency of mutual direct contacts suggests an increase in information processing requirements. This increase can be attributed directly to the addition of an assistant manager who was to manage the new client/server system. As shown by the

network diagram in figure 14, the assistant manager added to the frequency of contacts for the business process.

Number of versions (P-2)

The number of versions of schedules generated did not change. No change in the number of versions of schedules suggests no change in the level of uncertainty related to this variable.

The level of activity (P-3)

The level of activity was measured by the time taken to complete the whole business process. The level of activity increased from 350 minutes to 645 minutes because of the time taken for the client/server system to generate the schedules for the month. Before the implementation of the client/server system, each foreman would generate a schedule for the machines they were responsible for. After implementation of the client/server system, all the schedules were generated by the client/server application. As a result, more time was needed for the application to sort through all the equipment records. Effectively, the client/server system transformed several processes that used to run concurrently into a sequential process.

Pattern-Matching Logic for Propositions P-1, P-2, and P-3

Propositions P-1, P-2, and P-3 test for any change in the level of uncertainty experienced by the business process. The following pattern was expected if the client/server system had changed the level of uncertainty. The system should have

reduced uncertainty in the scheduling process by either increasing the information processing capacity, or reducing information processing requirement. As the amount of equipment and number of employees did not change, the quantity of information processed by the business process had not change. Therefore, the objective of the client/server system should be to reduce the information processing requirement of the staff maintaining the equipment by either (1) reducing the frequency of mutual direct contacts usually performed, (2) increasing the number of versions of schedules or information about schedules generated, or (3) reducing the total time taken to perform the scheduling process. According to the evidence collected, none of these propositions took place at Electric Co. After the implementation of the client/server system, the frequency of mutual direct contacts increased, the same versions of schedules were generated, and the total time taken to complete the scheduling process increased, indicating an increase in uncertainty. Table 10 shows the relationship between the change in client/server centrality and the variables measuring uncertainty.

Table 10. -- Client/server centrality and uncertainty

Change in Client/Server Centrality	Intervening Variable	Percentage Change
0.29	Frequency of mutual contacts	195%
	Number of versions	0%
	Level of activity (time)	84%

Changes in the Business Process

Propositions P-4 through P-9 test for changes experienced by the business process. The following observations were recorded for each of the propositions.

The number of employees in sequential tasks (P-4)

The number of employees in sequential tasks increased from five to six after the implementation. This increase is an unfavorable change in the business process as a consequence of the increase in the information processing requirements of the business process. This increase can be attributed to the addition of an employee into the business process whose function was to enter data and distribute generated schedules to the appropriate staff. Consequently, instead of compressing sequential functions, an additional function was added to the business process.

The number of employees vertically within the managerial hierarchy (P-5)

The number of employees within the managerial hierarchy increased from four to five. This increase is also an unfavorable change in the business process due to the addition of the same assistant manager who was to manage the client/server system. No compression of tasks within the managerial hierarchy took place.

Reachability index between customer and point of decision (P-6)

The customer of the business process was the foreman, who was to perform the work in the field. The decision maker in the process was the clearance coordinator. The

network diagram shows that the foreman did not have a direct link to the clearance coordinator before or after the implementation of the client/server application. The foreman required two steps (via the supervisor) to reach the clearance coordinator. This path distance did not change as a result of implementing the client/server application.

The amount of slack resources (P-7)

Although there was little, if any, slack in the performance of the work itself, there was two days' slack time available for the clearance coordinator to finalize the schedule (Wednesday through Friday). In other words, after the implementation of the client/server system, scheduling was still performed over a weekly cycle. The client/server application did not reduce this slack.

The number of concurrent tasks (P-8)

No concurrent tasks were created after implementation of the client/server system. An increase in the number of concurrent tasks would be expected if there was an increase in the information processing capacity of the business process.

Number of direct linkages between concurrent tasks (P-9)

No direct linkages between concurrent tasks were created because no concurrent tasks were created within the business process.

Pattern-Matching Logic for
Propositions P-4 through P-9

Pattern-matching logic suggests that if there was a reduction in the level of uncertainty due to a reduction in the information processing requirements, propositions P-4, P-5, P-6, and P-7 would show a negative change in either one or more of their measures. If there was a reduction in uncertainty due to an increase in information processing capacity, propositions P-8 and P-9 would show a positive change in either one or both of their measures.

Table 11. -- Uncertainty and business process change

Changes in Uncertainty		Business Process Change	% Change
Intervening Variable	% Change		
Frequency of mutual contacts	195%	P-4: Number of employees sequentially	20%
Number of versions	0%	P-5: Number of employees vertically	25%
Level of activity (time)	84%	P-6: Reachability index	0%
		P-7: Amount of slack	0%
		P-8: Number of concurrent tasks	0%
		P-9: Number of linkages between tasks	0%

However, the evidence collected suggests an increase in uncertainty due to an increase in information processing requirements. Therefore, the expected results would be a positive change in either one or more of propositions P-4, P-5, P-6, and P-7. As shown

in table 11, a positive change occurred to the number of employees in sequential tasks and the number of employees within the managerial hierarchy. Similarly, the evidence collected shows no reduction in uncertainty due to an increase in information processing capacity. Therefore, no changes would be expected from the variables tested by propositions P-8 and P-9. As predicted by the research framework, no changes occurred to measures for propositions P-8 and P-9.

Discussion of Results

According to Electric Co., the client/server application was designed to reduce the amount of maintenance work and repair necessary for Electric Co.'s equipment. The application acted as a depository of information on each piece of equipment, documenting all events experienced by the equipment, whether they were breakdowns or preventive maintenance. The expected result of this aggregation of information was a more cost-effective schedule that should allow Electric Co. to better organize its limited work force. The objective of this study, however, was to examine the effect of that client/server system on the scheduling process, not the effectiveness of that system. This distinction is crucial in order to understand the analysis of the data that were collected.

The scheduling process employed by Electric Co. was based on a weekly cycle that matched the technology and method of work used by the company. The technology used was a combination of a manual, paper-based system coupled with the foremen's and supervisors' experience in working with all the related equipment. The scheduling process depended on the need for agreement among the supervisors and key personnel of the

company that (1) the information concerning the equipment that needed to be maintained was accurate, and (2) the resources -- components and manpower -- to perform the maintenance work would be available when needed. If the client/server system helped meet these requirements, the company should see a change in the scheduling process. The research did not collect data to test if the application fitted the requirements of the business process, only, to test if the database scope is related to the level of uncertainty and business process change.

If a reduction in information processing requirement had actually occurred, the expected outcome of this case study, assuming that none of the rival explanations took place, would be:

1. Fewer employees would be needed to be involved, sequentially or vertically up the hierarchy, in the scheduling process. A possible scenario illustrating this effect is where the client/server system automatically collects maintenance information from the equipment and assigns appropriate staff to perform the repair.
2. The maintenance information reaches the foremen responsible directly, without the need for a supervisor or clearance coordinator to manage that information.
3. The amount of slack is reduced to the point where there will be no need to reenter maintenance information into different computer systems, and no need to coordinate maintenance information among the various transmission or distribution centers. The client/server system should eliminate the weekly cycle in the

scheduling process, forcing the company to work on a flexible, event-driven schedule without any time-consuming weekly deadlines.

The strategy chosen by the company to implement the client/server system was to appoint an assistant who was to oversee the operations and management of the client/server system. As discussed in the previous section, the implementation of the client/server system increased the level of uncertainty experienced by the business process, and consequently made the business process more complex. Very little change took place with regard to the other tasks that made up the scheduling process. The method with which the different parties came together to agree on a schedule remained the same as before the implementation of the client/server system. The client/server system did not address the information requirements of the scheduling system. Consequently, no favorable changes occurred in the business process.

Second Business Process: Edible Oil Co.

The second business process was a scheduling and monitoring system for a major edible oil manufacturer (henceforth referred to as Edible Oil Co.). Edible Oil Co. employed about 200 workers in Fort Worth, Texas in 1994. The site in Fort Worth comprised divisions that performed sales, accounting, transportation, and production. The production employees worked in three shifts to produce about seven million pounds of edible oil per week. Edible Oil Co. had manufacturing facilities at four other sites, and two administrative offices across the U.S. Hired trucks and customers' trucks were used to transport the oil from the manufacturing facilities to Edible Oil's customers.

Transport Scheduling and Monitoring System

The function of the transport scheduling and monitoring process was threefold: (1) to schedule trucks, (2) to record and monitor when a truck arrived and how long it took to load the oil, and (3) to document the exchange of wooden pallets used in the loading process. Edible Oil Co. exchanged about $250,000 worth of pallets annually with hired trucks. Edible Oil Co. needed to track the pallets so that it could demand compensation if truck carriers did not return any of the pallets. The business process generated schedules and reports that were used both by internal management and the customers of the company.

A customer would call in and order a product from the sales department a few days (from three days to a week) before the actual pickup or shipment date. The sales department would enter the order into the company mainframe. The order was set up for shipment using either a truck carrier that the company hired, or the customer's own truck. The transportation department copied the order from the mainframe into a shipping schedule that was typically scheduled for the next day. The transportation department took reports from the mainframe and assigned carriers to each shipment based on a rating scale and the route that the carrier would take. When the truck arrived for loading, the guard at the gate would enter the time the truck arrived, and the loading process would begin. The loading staff would load the oil into the truck and would fill out the bill of lading with the time the loading began, the time taken to load, the time loading was complete, and the number of pallets of oil received and taken out. The bill of lading

would go back to the transportation department, who entered the pallet information into the pallet monitoring system. The supervisor and employees in the transportation department would hand type the information from the bill of lading into a Lotus spreadsheet for analysis and reporting purposes. The supervisor also generated a monthly pallet balance report for the truck carriers. The loading report, showing the efficiency of the company's loading process, was given to the plant manager and the warehouse manager.

Description of the Client/Server System

The old technology was a combination of a dBase program that handled the scheduling process, a Lotus 123 spreadsheet that handled the loading times and pallet balances, and various paper-based notes. The new client/server system was a FoxPro for Windows application that ran on an IBM LAN Manager server machine. An outside consultant designed and programmed the application. The application consisted of several FoxPro tables and programs that integrated information from the old dBase program, the Lotus 123 spreadsheet, and the paper-based notes. The staff interacted with the application via a series of GUI menus and forms. The consultant took three months to complete the application and involved the staff of Edible Oil Co. throughout the development process of the application. The transportation department accessed the application from their workstations. The staff entered information into the application using the keyboard. The application printed out schedules and various reports for the company.

Data Analysis

The name of the business process analyzed was the transportation scheduling and monitoring system. The business process generated a series of schedules and reports. The customers of the business process were both internal and external. The internal customer was the management of the company who tracked the schedules, the loading efficiency reports, and the pallet balances. The external customers were the carriers and customers who received the loading reports and pallet balances. The network diagram for the process before and after the implementation of the client/server system (CSS) is shown in figures 15 and 16, respectively.

Tables 12 and 13 show the relationship matrices for network diagrams in figures 15 and 16, respectively. Tables 14 and 15 show the reachability matrices R^2 for the relationship matrices in tables 12 and 13, respectively. R^2 corresponds to whether or not actor i can reach actor j in T or fewer steps. R^2 is calculated using the formula:

$$R^T = K + K^2 + K^3 + ... + K^T$$

where K^T is the relationship matrix multiplied by itself T number of times.

Table 16 shows the tasks that made up the business process before and after the implementation of the client/server application. The first column defines the person performing the tasks, the second column contains a brief description of the task, the third column contains the time taken for that individual to do the tasks, and the fourth column

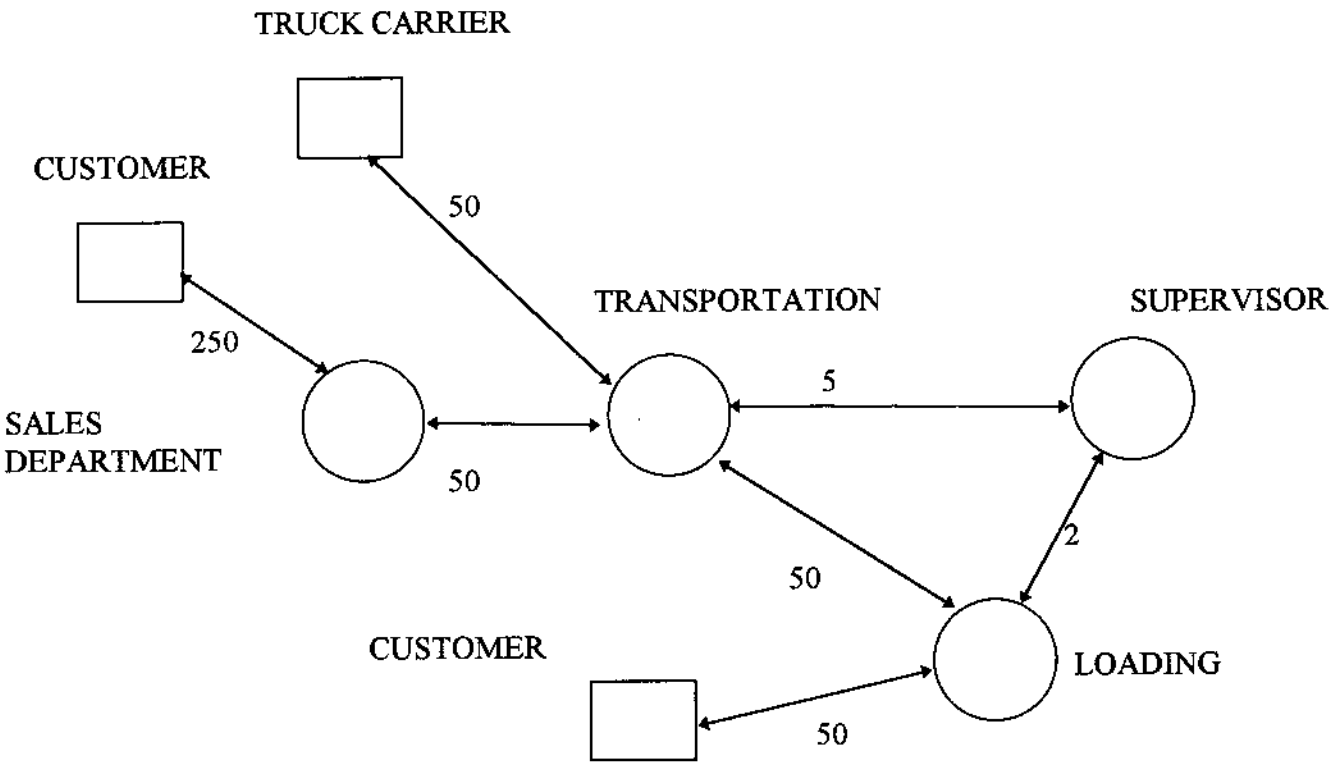

Fig. 15. Edible Oil Co.'s business process network diagram before implementation

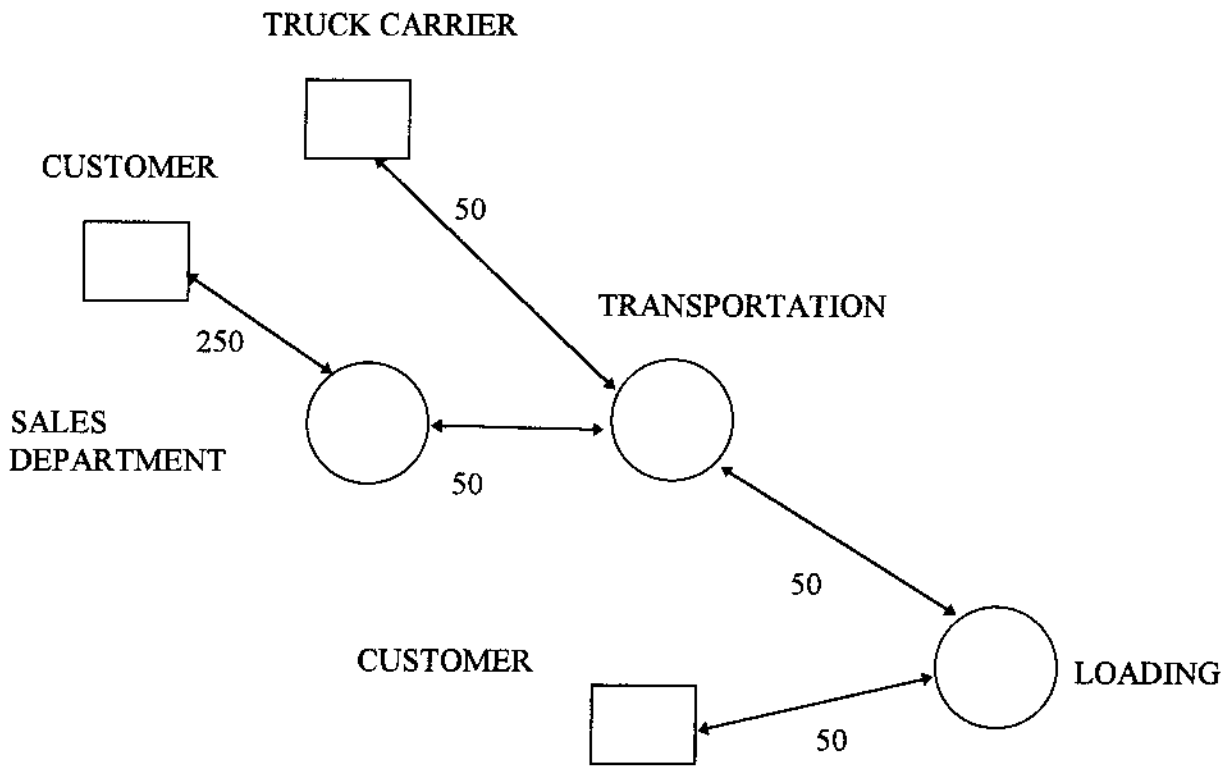

Fig. 16. Edible Oil Co.'s business process network diagram after implementation

Table 12. -- Edible Oil Co.'s relationship matrix before implementation

	Carrier	Customer	Transpor-tation	Super-visor	Sales	Loading	CSS	Degree of point	Sum of frequencies
Carrier	0	0	50	0	1	0	0	2	51
Customer	0	0	0	0	250	50	0	2	300
Transpor-tation	50	0	0	5	50	50	0	4	155
Super-visor	0	0	5	0	0	2	0	2	7
Sales	0	250	50	0	0	0	0	2	300
Loading	0	50	50	2	0	0	0	3	102
CSS	0	0	0	0	0	0	0	0	0
Degree of point	1	2	4	2	3	3	0	15	
Sum of frequencies	50	300	155	7	301	102	0		915

Table 13. -- Edible Oil Co.'s relationship matrix after implementation

	Carrier	Customer	Transpor-tation	Sales	Loading	CSS	Degree of Point	Sum of Frequencies
Carrier	0	0	50	1	0	0	2	51
Customer	0	0	0	250	50	0	2	300
Transpor-tation	50	0	0	50	50	50	4	150
Sales	0	250	50	0	0	0	2	300
Loading	0	50	50	0	0	0	2	100
CSS	0	0	50	0	0	0	1	50
Degree of point	1	2	4	3	2	1	13	
Sum of frequencies	50	300	200	301	100	50		901

Table 14. -- Edible Oil Co.'s reachability matrix R^2 before implementation

	Carrier	Customer	Transportation	Supervisor	Sales	Loading
Carrier	1	1	2	1	2	1
Customer	0	2	2	1	1	1
Transportation	1	2	4	2	2	2
Supervisor	1	1	2	2	1	2
Sales	1	1	1	1	2	2
Loading	1	1	2	2	2	3

Table 15. -- Edible Oil Co.'s reachability matrix R^2 after implementation

	Carrier	Customer	Transportation	Sales	Loading
Carrier	1	1	2	2	1
Customer	0	2	2	1	1
Transportation	1	2	3	2	1
Sales	1	1	1	2	2
Loading	1	1	1	2	2

Table 16. -- Task table for Edible Oil Co.'s business process

Person(s) or group performing task	Brief description of tasks	Time before CSS (min.)	Slack before CSS	Time after CSS (min.)	Slack after CSS
Customer	Calls sales department	15	3 days	15	3 days
Transportation	Calls carriers	60		60	
Transportation	Writes up shipping schedule	10		10	
Transportation	Enters changes to schedule	15		15	
Carrier/ Customer and Loading	Arrives and is logged in by guard and loading staff	10		10	
Transportation	Enters pallet information	20		15	
Transportation	Enters pallet information	N/A		10	
Transportation	Enters loading times	N/A		10	
Supervisor	Enters loading times	45		N/A	
Supervisor	Generates loading times summary	8 hours	2 days	N/A	N/A
Transportation	Pallet reports	15		10	
Totals		11 hours 10 min.	5 days	155 min. (2 hours 35 min.)	3 days

Table 17. -- Edible Oil Co.'s summary of evidence

Variables	Measures			
	Pretest	Posttest	Difference	
Centrality of CSS	0	0.15	0.15	
Frequency of mutual direct contacts.....	458	450	-8	Positive or negative difference indicates change in uncertainty
Number of versions	4 reports	6 reports	2	
Level of activity (time taken)....	670	155	-515	
Number of employees in sequential tasks	3	2	-1	Negative difference indicates a change due to a reduction in information processing requirements
Number of employees vertically	3	2	-1	
Reachability index between customer and point of decision	1	1	0	
Amount of slack in finalizing schedule	5 days	3 days	-2	
Number of concurrent tasks	0	0	0	Positive difference indicates a change due to an increase in information processing capacity
Number of direct linkages between concurrent tasks	0	0	0	

contains any slack time for each task before the implementation of the client/server system. The fifth column contains any slack time for each task after the implementation of the client/server system.

Table 17 shows the summary of the evidence collected. This table is developed using the information from the network diagrams, the relationship matrices, the reachability matrices, and the task table.

Changes in the Level of Uncertainty

Propositions P-1, P2, and P3 test for changes in the level of uncertainty experienced by the business process. If the frequency of mutual contacts, the number of versions of products or services, or the time taken to complete the business process changes after the implementation of the client/server system, the research framework suggests that the business process has experienced a change in the level of uncertainty.

Frequency of mutual direct contacts (P-1)

The decrease in the frequency of mutual direct contacts from 458 to 450 shows that the business process had experienced a change in the level of uncertainty. Because the amount of information processed by the organization had not changed significantly in the period that the client/server system is implemented, the decrease in the frequency of mutual direct contacts suggests a decrease in information processing requirements. This decrease can be attributed to the client/server system. Using the client/server system, the

transportation department was able to perform the tasks (pallet balance management and loading efficiency tracking and reporting) that were performed by the factory supervisor.

Number of versions (P-2)

Before the implementation of the client/server process, four reports were generated by different applications:

1. daily shipping schedule was generated by the dBase program
2. loading report was generated using Lotus spreadsheets
3. pallet report by carrier was generated by the dBase program
4. summary of pallet balances for all carriers was generated using Lotus spreadsheets.

After the implementation, six reports were generated by the single FoxPro database system:

1. daily shipping schedule
2. loading report by carrier
3. loading report for all carriers
4. pallet report by carrier
5. pallet report for all carriers
6. summary of pallet balances for all carriers.

The number of versions of reports increased after the implementation of the client/server system. Because no significant change had occurred to the amount of information processed by the business process in the period that the client/server system was implemented, the increase in the number of versions suggests a decrease in the

information processing requirements of the business process. This decrease can be attributed to the new client/server application: After the implementation, it was generating more reports without the need for any of the staff to process that information.

The level of activity (P-3)

The level of activity is measured by the time taken to complete the whole business process. The time taken to complete the whole business process had changed significantly from 670 minutes down to 155 minutes because many of the manual tasks, such as reentering loading data and generating loading efficiency and pallet balance reports were generated by the client/server system. The total time reflects the actual total time it took to complete the business process. As a result, the level of uncertainty of the business process decreased significantly.

Pattern-Matching Logic for Propositions P-1, P-2, and P-3

Propositions P-1, P-2, and P-3 test for any change in the level of uncertainty experienced by the business process. The following pattern was expected if the client/server system had changed the level of uncertainty. The system should reduce uncertainty in the scheduling process by either increasing the information processing capacity or reducing information processing requirement. As neither the number of customers and truck carriers nor the number of employees in Edible Oil Co. significantly changed during the period between pre- and post-implementation data collection, the client/server system should have reduced the information processing requirement of the

business process. The reduction in information processing requirement is achieved by either (1) reducing the frequency of mutual direct contacts usually performed, (2) increasing the number of versions of products generated, or (3) reducing the total time taken to perform the scheduling process. According to the evidence collected, all three propositions took place at Edible Oil Co. After the implementation of the client/server system, the frequency of mutual direct contacts decreased slightly, more versions of reports were generated, and the total time taken to complete the scheduling process decreased significantly. This evidence suggests that information processing requirement was reduced. Table 18 shows the relationship between the change in client/server centrality and the variables measuring uncertainty.

Table 18. -- Client/server centrality and uncertainty

Change in Client/Server Centrality	Intervening Variable	Percentage Change
0.15	Frequency of mutual contacts	-8%
	Number of versions	50%
	Level of activity (time)	-77%

Changes in the Business Process

Propositions P-4 through P-9 test for changes experienced by the business process. The following observations were recorded for each of the propositions:

The number of employees in sequential tasks (P-4)

The number of employees in sequential tasks decreased from three to two after the implementation. This decrease is a favorable change in the business process as a consequence of the decrease in the information processing requirements of the business process. This decrease can be attributed directly to the new client/server application, as it enabled transportation to perform tasks that were previously performed by the supervisor. Consequently, a change in the business process in the form of a compression of sequential functions occurred.

The number of employees vertically within the managerial hierarchy (P-5)

The number of employees within the managerial hierarchy decreased from three to two. This decrease in the number of employees vertically can be attributed to the client/server system, as the supervisor of the transportation staff was no longer required to perform loading efficiency and pallet balance tracking and reporting. A change in the form of a compression in vertical tasks occurred within the business process.

Reachability index between customer and point of decision (P-6)

No change occurred with the reachability index because the customer was directly in contact with the decision maker in the business process before and after the implementation.

The amount of slack resources (P-7)

The amount of slack resources used by the business process decreased from five days to three days. The two days' slack time eliminated was the time usually needed to perform the data entry and reporting for the loading efficiency and pallet balance tasks. A change in the business process in the form of a reduction in slack occurred.

The number of concurrent tasks and linkages between concurrent tasks (P-8 and P-9)

No concurrent tasks were created as a result of the implementation of the client/server system; hence no linkages were created.

Pattern-Matching Logic for Propositions P-4 through P-9

Pattern-matching logic suggests that if there was a reduction in the level of uncertainty due to a reduction in the information processing requirements, propositions P-4, P-5, P-6, and P-7 would show a negative change in either one or more of their measures. If there was a reduction in uncertainty due to an increase in information processing capacity, propositions P-8 and P-9 would show a positive change in either one or both of their measures.

The evidence collected suggests a decrease in uncertainty due to a decrease in information processing requirements. Therefore, the expected results would be a negative change in either one or more of propositions P-4, P-5, P-6, and P-7. As shown in table 19, a negative change occurred to the number of employees sequentially, the number of

employees vertically, and the amount of slack. This pattern is consistent with the predicted pattern. Also, as no increases in the information processing capacity of the business process was observed, no changes occurred to measures for propositions P-8 and P-9.

Table 19. -- Uncertainty and business process change

Changes in Uncertainty		Business Process Change	% Change
Intervening Variable	% Change		
		P-4: Number of employees sequentially	-33%
		P-5: Number of employees vertically	-33%
Frequency of mutual contacts	-2%	P-6: Reachability index	0%
Number of versions	50%	P-7: Amount of slack	-40%
Level of activity (time)	-77%	P-8: Number of concurrent tasks	0%
		P-9: Number of linkages between tasks	0%

Discussion of Results

According to the evidence collected in this study, changes in the business process were found as a result of the implementation of the FoxPro application. The application enabled the transportation department to perform tasks that a manager was previously performing, thereby reducing the total number of employees required for the task and improving the productivity of the employees in the business process. The application also

reduced the slack required by the business process, improving customer service and productivity.

Third Business Process: InfoCom Corp.

The third business process was an order entry and purchasing system for a computer systems reseller and integrator, InfoCom Corp., located in Richardson, Texas. InfoCom Corp. had 21 employees in 1994, five of whom were sales agents. InfoCom Corp. generated about $5.5 million worth of sales in 1994, the majority of which were from overseas customers.

The Order Entry and Purchasing Process

The objective of the order entry and purchasing system was to assist sales agents in selling computer and telecommunication products to InfoCom Corp.'s customers. Customers would either call in or fax their requests for quotes to InfoCom daily. Sales agents at InfoCom would try to give the best quote to persuade their customers to confirm the sale. To perform this task, the sales agents accessed distributors' electronic catalogs, various CD-ROM product catalogs, or searched for the information they needed in printed catalogs, magazines, or other literature. If they could not find the product, they could call on vendors or other sales agents for information. When all the information was collected, the sales agent would prepare a quote and fax that quote to the customer. If the customer liked the quote, the customer would send back a confirmation, using either a purchase order number, a credit card number, or some other form of order confirmation. The

confirmed quotes were converted into proforma invoices, and together with the confirmation order, were sent to accounting for credit checks. If accounting approved the sale, it would send a sales order to the sales agent, who then started the purchasing process from a vendor or manufacturer. The customer's purchase order would be sent to accounting for inventory processing.

After the merchandise arrived, accounting would visually check the product to make sure it fit the proforma invoice and order confirmation. If there were any problems, the product would be shipped back to the vendor or manufacturer. If there were no problems, accounting would pack and ship the product. An invoice was generated and reconciled with the purchase order. Depending on the customer, payment was made using either credit card information, a letter of credit, a wire transfer, or a down payment. Accounting would follow up on an invoice to make sure the customer pays within the credit terms given. This old system was largely manual and was very cumbersome.

Description of the Client/Server System

The old technology was a combination of desktop computers that had various electronic catalogs, a word processor to write out quotes and proforma invoices, and a spreadsheet to perform various tasks. The new system, based on Lotus Notes, performed two major tasks:

1. Automate the job of searching for the product.
2. Reduce the paper trail and reconciliation process.

The Lotus Notes application comprised four databases, a quotes history database, a sales order and purchasing database, a customer database, and a vendor database. The quotes history, customer, and vendor databases were replicated to all sales agents' desktop computers at hourly intervals. Only the sales order database was located on the server and could be accessed via the network. Using periodic replication, a central database was updated. Therefore, the sales agents were able to use their desktop computer processing power, without needing to access the central server with their daily tasks. Every time a sales agent filled out a quote form, the information was saved into the quotes history database. That way, all the research and effort expended by the sales agents were stored, and made available to other sales agents. The system also automated data entry such that data entry was required only once, and that data would be available to all users at a click of a button. As soon as the sales agent found the needed information, the new system automatically generated a quote, and that quote was faxed to the customer. If the customer confirmed the quote, the sales agent could automatically check the customer's credit. If the customer's credit was acceptable, the quote was electronically converted into a proforma invoice and sales order. Purchase orders were automatically generated from the sales order and the sales agent could then order the product from vendors. Once the ordered product arrived at the warehouse, the accounts staff would scan the manufacturer's bar code, and reconcile the product with existing purchase orders and sales orders.

Data Analysis

The name of the business process was the order entry and purchasing system. The business process generated a variety of products and services: (1) product information, (2) quotations, (3) proforma invoices, (4) customer credit checks (5) sales orders, and (6) purchase orders. The customers of the business process were both internal and external. The internal customers were InfoCom's sales and accounting staff. The external customers were InfoCom's customers, who happened to be mostly computer dealers or large corporations. The network diagram for the process, before and after the implementation of the client/server system, is shown in figures 17 and figure 18, respectively.

Tables 20 and 21 show the relationship matrices for network diagrams in figures 17 and 18, respectively. Tables 22 and 23 show the reachability matrices R^2 for the relationship matrices in tables 20 and 21, respectively. R^2 corresponds to whether or not actor i can reach actor j in T or fewer steps. R^2 is calculated using the formula:

$R^T = K + K^2 + K^3 + ... + K^T$

where K^T is the relationship matrix multiplied by itself T number of times.

Table 24 shows the tasks that made up the business process before and after the implementation of the client/server application. The first column defines the person performing the tasks, the second column contains a brief description of the task, the third column contains the time taken for that individual to do the tasks, and the fourth column

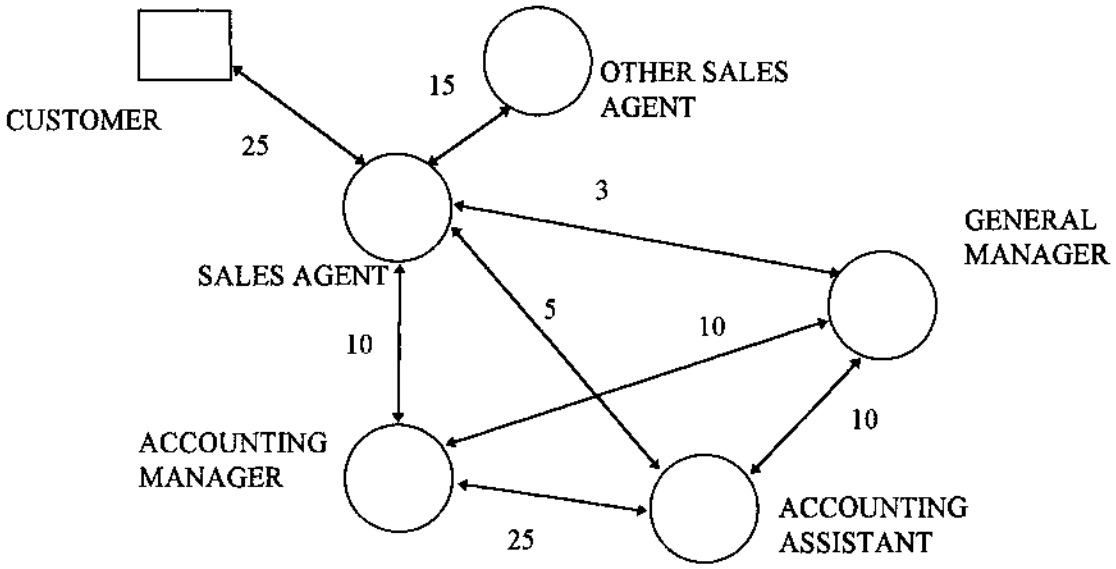

Figure 15. InfoCom's business process network diagram before implementation

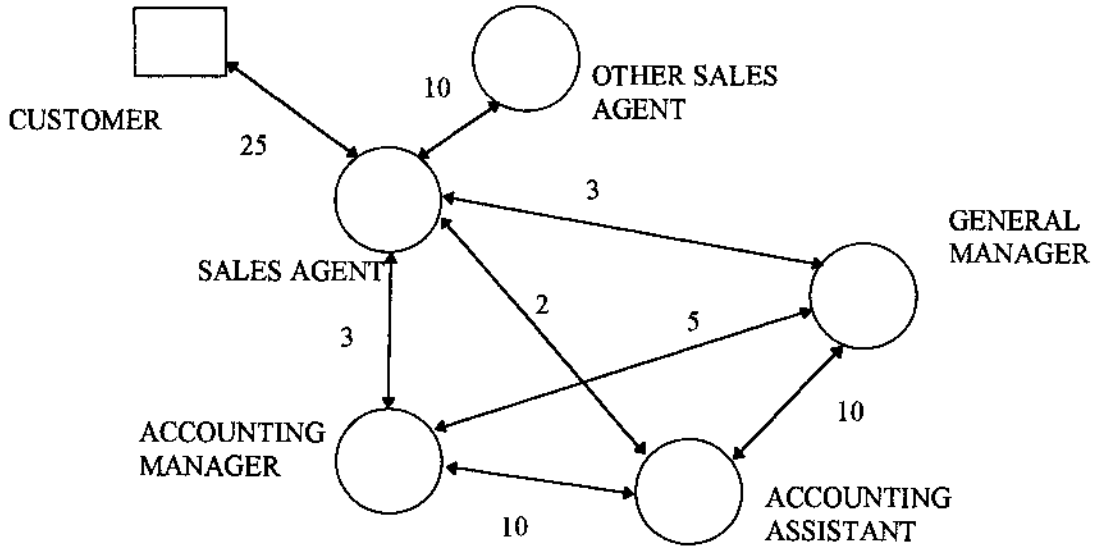

Fig. 16. InfoCom's business process network diagram after implementation

Table 20. -- InfoCom's relationship matrix before implementation

	Customer	Sales Agent	Other Agents	Accounts Manager	Assist-ant Accoun-tant	General Manager	CSS	Degree of actor	Sum of frequencies
Customer	0	25	0	0	0	0	0	1	25
Sales Agent	25	0	15	10	5	3	0	5	58
Other Agents	0	15	0	0	0	0	0	1	15
Accounts Manager	0	10	0	0	25	10	0	3	45
Assistant Accountant	0	5	0	25	0	10	0	3	40
General Manager	0	3	0	10	10	0	0	3	23
CSS	0	0	0	0	0	0	0	0	0
Degree of Point	1	5	1	3	3	3	0	16	
Sum of Frequencies	25	58	15	45	40	23	0		206

Table 21. -- InfoCom's relationship matrix after implementation

	Customer	Sales Agent	Other Agents	Accounts Manager	Assist-ant Accoun-tant	General Manager	CSS	Degree of Point	Sum of Frequencies
Customer	0	25	0	0	0	0	0	1	25
Sales Agent	25	0	10	3	2	3	25	6	43
Other Agents	0	10	0	0	0	0	25	2	10
Accounts Manager	0	3	0	0	10	5	10	4	18
Assistant Accountant	0	2	0	10	0	10	25	4	22
General Manager	0	3	0	5	10	0	10	4	18
CSS	0	25	25	10	25	10	0	5	95
Degree of Point	1	6	2	4	4	4	5	21	
Sum of Frequencies	25	43	10	18	22	18	95		136

Table 22. -- InfoCom's reachability matrix R^2 before implementation

	Customer	Sales Agent	Other Agents	Accounts Manager	Assistant Accoun-tant	General Manager
Customer	1	1	1	1	1	1
Sales Agent	1	5	1	3	3	3
Other Agents	1	1	1	1	1	1
Accounts Manager	1	3	1	3	3	3
Assistant Accoun-tant	1	3	1	3	3	3
General Manager	1	3	1	3	3	3

Table 23. -- InfoCom's reachability matrix R^2 after implementation

	Customer	Sales Agent	Other Agents	Accounts Manager	Assistant Accountant	General Manager
Customer	1	1	1	1	1	1
Sales Agent	1	5	1	3	3	3
Other Agents	1	1	1	1	1	1
Accounts Manager	1	3	1	3	3	3
Assistant Accountant	1	3	1	3	3	3
General Manager	1	3	1	3	3	3

Table 24. -- Task table for InfoCom's business process

Person(s) performing task	Brief description of tasks	Time before CSS (min.)	Slack before CSS	Time after CSS (min.)	Slack after CSS
Sales	Receive fax and read request	10		10	
	Search for products	10 min. to 2 days		5 min. to 1 day	
	Write quote	15		5	
	Send fax and receive confirmation	5	1-3 days	5	1-3 days
	Order product	5		5	
Accounting	Credit check	10	1 day	0	N/A
	Issue sales order	20		0	
	Receive product		4-5 days		4-5 days
	Check product	30		5	
	Pack product	20		20	
	Print invoice	20		5	
	Collect payment		30-60 days		30-60 days
	Total time	145 min. (2 hr. 25 min.) and up to over 2 days	36 days to 69 days	60 min. and up to over 1 day	35 days to 68 days

Table 25. -- InfoCom's summary of evidence

Variables	Measures			
	Pretest	Posttest	Difference	
Centrality of CSS	0	0.48	0.48	
Frequency of mutual direct contacts.....	103	68	-35	Positive or negative difference indicates change in uncertainty
Number of versions	1	5	4	
Level of activity (time taken).....	145 min.	60 min.	-85	
Number of employees in sequential tasks	5	5	0	Negative difference indicates a change due to a reduction in information processing requirements
Number of employees vertically	2	2	0	
Reachability index between customer and point of decision	1	1	0	
Amount of slack in completing process.....	36 days	35 days	-1	
Number of concurrent tasks	5	5	0	Positive difference indicates a change due to an increase in information processing capacity
Number of direct linkages between concurrent tasks	0	10	10	

contains any slack time for each task before the implementation of the client/server system. The fifth column contains any slack time for each task after the implementation of the client/server system.

Table 25 shows the summary of the evidence collected. This table is developed using the information from the network diagrams, the relationship matrices, the reachability matrices, and the task table.

Changes in the Level of Uncertainty

Propositions P-1, P2, and P3 test for changes in the level of uncertainty experienced by the business process. If the frequency of mutual contacts, the number of versions of products or services, or the time taken to complete the business process changes after the implementation of the client/server system, the research framework suggests that the business process has experienced a change in the level of uncertainty.

Frequency of mutual direct contacts (P-1)

The frequency of mutual direct contacts changed from 103 to 68. This decrease shows that the business process had experienced a change in the level of uncertainty. Since the number of customers and number of employees had not changed significantly in the period that the client/server system was implemented, the decrease in the frequency of mutual direct contacts measured the decrease in information processing requirements. This decrease can be attributed directly to the decrease in the need for InfoCom's

employees to communicate and coordinate information among themselves. Many of the tasks that were performed manually were being replaced by the client/server system.

The coordinative and communicative tasks that were reduced or eliminated were (Table 24): (1) searching for products, (2) checking the credit level of the customers, and (3) issuing sales orders. Before the implementation of the client/server system, sales agents spent an inordinate amount of time searching for products and consulting among themselves. Also, InfoCom's accounting staff consisted of only two people. The accounts manager was inundated by order confirmations and credit check requests from sales agents, resulting in delays in the issuance of sales orders for customers. After the implementation of the client/server system, credit checks were automatically performed by the new system. If the credit check was successful, a proforma invoice and sales order were automatically generated for the sales agent.

Number of versions (P-2)

The business process generates a variety of products and services: (1) product information, (2) quotations, (3) proforma invoices, (4) customer credit checks (5) sales orders, and (6) purchase orders. Before the implementation of the client/server system, each agent worked with his or her own set of resources for writing quotes. Whatever research they performed was the only source of help for them in their effort to locate the best product for their customer. After the implementation of the client/server system, each sales agent could access, on-line, the experience and history of research performed by

other sales agents via Lotus Notes. The number of versions of product prices, vendor information, quotes, sales orders, purchase orders increased. The sales agent was able to browse and select any quote or sales order that had been processed and search using keywords to find the desired product from four other sources. Therefore the number of versions of products and services increased from 1 to 5.

A significant change had occurred to the amount of information processed by the business process after the client/server system was implemented. Therefore, the increase in the number of versions suggests an increase in information processing capacity of the business process.

The level of activity (P-3)

Time was the measure used for the level of activity to complete the whole business process. The time taken to complete the whole business process decreased from 145 minutes to 60 minutes. This decrease was because the client/server system performed many of the manual tasks shown in table 24. Since the number of customers and number of employees had not changed significantly in the period that the client/server system was implemented, the decrease in the frequency of mutual direct contacts measured the decrease in information processing requirements. The total time reflects the actual total time it took to complete the business process. As a result, the level of uncertainty of the business process decreased.

Pattern-Matching Logic for Propositions P-1, P-2, and P-3

Propositions P-1, P-2, and P-3 test for any change in the level of uncertainty experienced by the business process. The following pattern was expected if the client/server system had changed the level of uncertainty. The system should reduce uncertainty in the scheduling process by either increasing the information processing capacity or reducing information processing requirements. Both a reduction of information processing requirements and an increase in information processing capacity occurred at InfoCom Corp. The reduction in information processing requirement is achieved by either (1) reducing the frequency of mutual direct contacts usually performed, (2) increasing the number of versions of products generated, or (3) reducing the total time taken to perform the scheduling process. According to the evidence collected, all three propositions took place at InfoCom Corp. Table 26 shows the relationship between the change in client/server centrality and the variables measuring uncertainty.

Table 26. -- Client/server centrality and uncertainty

Change in Client/Server Centrality	Intervening Variable	Percentage Change
0.48	Frequency of mutual contacts	-34%
	Number of versions	400%
	Level of activity (time)	-59%

Changes in the Business Process

Propositions P-4 through P-9 test for changes experienced by the business process. The following observations were recorded for each of the propositions.

The number of employees in sequential and vertical tasks (P-4 and P-5)

No change occurred in the number of employees in sequential tasks or vertical tasks at InfoCom Corp. although a decrease in uncertainty was observed. The reason for the lack of change in the business process can be attributed to the small number of nodes in the business process network. InfoCom Corp. was a small company, and only six nodes were present in the business process network diagram as shown in figures 17 and 18. Also, the company culture and style of leadership may be other moderating variables that prevented InfoCom from reducing the number of employees in the sequential and vertical tasks.

Reachability index between customer and point of decision (P-6)

No change occurred in the reachability index, as the customer was directly in contact with the decision maker (the sales agent) in the business process before and after the implementation.

The amount of slack resources (P-7)

In the order entry system, much of the slack time was taken waiting for quotes from vendors, waiting for conformation from customers, waiting for products to arrive from distributors, and waiting for payment from customers. The client/server system

appeared to have at least reduced the slack time in searching for the product. Using search facilities available within the system, sales agents were able to narrow their search.

The number of concurrent tasks and linkages between concurrent tasks (P-8 and P-9)

Before the implementation of the client/server system, five sales agents were performing basically the same tasks concurrently. However, their work was largely independent of one another. Hence, no direct linkages existed between the tasks. After the implementation of the client/server system, the tasks of searching for products and entering quotes were linked. Every time a quote was written, that quote was replicated to other sales agents. Valuable information about products, vendors, prices, and customers was communicated before the completion of the business process.

Therefore, the number of direct linkages between concurrent tasks increased from zero to 10, which corresponds to the number of links possible for 5 sales agents. A change in the form of the creation of direct linkages between concurrent tasks occurred within the business process.

Pattern-Matching Logic for Propositions P-4 through P-9

Pattern-matching logic suggests that if there was a reduction in the level of uncertainty due to a reduction in the information processing requirements, propositions P-4, P-5, P-6, and P-7 would show a negative change in either one or more of their measures. If there was a reduction in uncertainty due to an increase in information

processing capacity, propositions P-8 and P-9 would show a positive change in either one or both of their measures.

According to the evidence collected, a reduction in the information processing requirements and an increase in the information processing capacity occurred simultaneously. This conclusion is not contradictory to the simultaneous decrease in information processing requirements, because the increase in the capacity occurred within the product search function of the order entry system. The amount of information available to sales agents was quadrupled, as each sales agent was able to access the experience and expertise of all the other sales agents on-line.

Because both a reduction in information processing requirement and an increase in information processing capacity had occurred, the business process needs to be broken down further into subprocesses. In this way, the effects of each of the intervening variables can be analyzed. The order entry and purchasing process is divided into the following subprocesses, as shown in table 27.

Within the search for product subprocess, which involves the five sales agents, an increase in information processing capacity was detected. As proposed by the research framework in figure 6, there should be either no reduction in the number of employees sequentially or vertically, no reduction in the amount of slack, or no reduction in the reachability index. The evidence collected supports all these propositions. Within the search for product subprocess, no change in the number of employees occurred either

Table 27. -- Order entry and purchasing subprocesses cross-referenced with evidence collected after the implementation

Person(s) performing	Sub processes	Brief description	Evidence after implementation
Sales	Product Search	Receive fax and read request	No change
		Search for product	Increased information processing capacity by generating more information for sales agents. Increased number of versions.
	Quote processing	Write quote	Reduced information processing requirement by automation. Decreased in level of activity and number of employee.
		Send fax and receive confirmation	No change. Each sales agent faxed a quotation using another software program.
Accoun-ting	Credit processing	Check credit	Reduced information processing requirement by automation. Sales agents accessed customer files automatically. Decreased level of activity and number of employees in sequential tasks.
		Issue sales order	Reduced information processing requirement by automation. Sales order are generated by system. Decreased level of activity, number of contacts and subsequently, number of employees.
Sales	Ordering	Order product	No change
Accoun-ting	Receiving	Receive product	No change
		Check product	Reduced information processing requirement by automation. Bar coding system sped up process of reconciliating packing slips with purchase orders and sales orders. Decrease in level of activity.
	Shipping	Pack product	No change
		Print invoice	No change
	Collection	Collect payment	No change

sequentially or vertically. Also, no significant change in the amount of slack occurred, and no change in the distance between the source of information and the point of decision took place.

Alternatively, the increase in the information processing capacity should show an increase in either the number of concurrent tasks in the business process, or an increase in the linkages between concurrent processes. The evidence collected showed that an increase in the number of linkages resulted from this increase in information processing capacity. By breaking down the business process into its subprocesses, the collected evidence concurred with the predicted results.

Within the quote processing subprocess, a reduction in information processing requirement was measured by a decrease in the level of activity. This decrease in information processing requirement should be reflected in either a decrease in the number of employees sequentially or vertically, a decrease in the amount of slack, or a decrease in the distance between the source of information and the point of decision. The collected evidence show that the sales agents no longer have to write quotations because the Lotus Notes application automatically generates them.

A similar logic can be applied in the case of all the succeeding subprocesses. In the case of credit processing, the customer of that subprocess was the sales agent, and the point of decision was the accounts manager. Since the sales agents could access the customer files automatically, the accounts manager was no longer necessary for that task, reducing the number of employees required sequentially and vertically. Additionally, the

distance between the sales agent and the point of decision was eliminated, since credit information was available via the client/server application.

In the case of the receiving subprocess, the accounting staff was overburdened with the task of reconciliation. This problem reached a point where often the sales staff would help the accounting staff find the products that were ordered, and reconcile the packing list with the purchase orders. Sometimes, the sales agents had to pack and ship the product. After the implementation of the client/server process, the time it took to reconcile the documents decreased such that the sales agents no longer needed to intervene.

According to the evidence collected in this study, a significant change in the business process was found as a result of the implementation of the Lotus Notes application. The application enabled each of the staff members to concentrate their efforts on what they were hired to perform. For example, the accounts manager was able to spend more time collecting from customers and managing the accounts of the company rather than following up on paperwork.

Cross-Case Analysis and Explanation Building

This section discusses the possibility of generalizing the research framework to all cases where client/server systems were implemented. The three case studies analyzed

Table 28. -- Change in intervening and dependent variables for all three cases

MODERATING VARIABLE	CASE STUDIES			
	Edible Oil Co.	Electric Co.	InfoCom Corp.	
Change in Centrality of client/server system	0.15	0.29	0.48	
NON-EQUIVALENT INTERVENING VARIABLES	PERCENTAGE CHANGE			COMMENTS
P-1: Frequency of mutual direct contacts	-2%	195%	-34%	Positive or negative change indicates change in uncertainty
P-2: Number of versions	50%	0%	400%	
P-3: Level of activity (time taken)	-77%	84%	-59%	
NON-EQUIVALENT DEPENDENT VARIABLES				
P-4: Number of employees in sequential tasks	-33%	20%	0%	Negative change indicates a change due to a reduction in information processing requirement
P-5: Number of employees vertically	-33%	25%	0%	
P-6: Reachability index between customer and point of decision	0%	0%	0%	
P-7: Amount of slack in completing process	-40%	0%	-3%	
P-8: Number of concurrent tasks.....	0%	0%	0%	Positive change indicates a change due to an increase in information processing capacity
P-9: Number of direct linkages between concurrent tasks	0%	0%	1000%	

offer a replication of client/server systems implementations that can be used to test the research framework. Explanation building is used to analyze the three case studies. The essence of explanation building is the iterative process of generating other plausible or rival explanations by refining the set of ideas and results collected in each case study.

Table 28 shows the results from all three cases arranged by the database scope of the client/server system. Centrality is used as a measure for database scope. Centrality, a network analysis metric (Knoke and Kuklinski 1982), is defined as a measure of the degree of involvement of a node in all the network relations.

Yin (1989) cautions that pattern matching is incapable of any precise comparisons. The quantitative values used in this research cannot be used to postulate any subtle patterns. Only the direction of the change is of any significance in this research. As shown by the data in table 28, the only case that does not fit the pattern predicted by the research framework is Electric Co. Instead of reducing uncertainty and improving business processes, the use of client/server systems is related to an increase in uncertainty and an unfavorable change in business processes. Explanation building can explain this inconsistency.

First, the application designed for Electric Co. may not have addressed the objectives of the business process. This lack of fit between the task and the technology (Goodhue and Thompson 1995) could result in an unfavorable change in the business process. Second, the variables in the research may have little construct validity, in which case none of the variables actually measured the intended constructs. Third, the case studies may not have internal validity. This means that other moderating variables were at work and were causing the pattern shown in table 28.

The first rival explanation concerns the lack of fit between the technology and the task it was supposed to address. Unfortunately, no data were collected to verify how well

the application met the needs of the business process after the implementation of the client/server system. The only indication of task-technology fit were the design objectives of the system as noted by the manager of the information systems department of Electric Co. The objective of the application was to collect information on Electric Co.'s equipment so that it could better maintain the equipment rather than to address the scheduling process.

The second rival explanation concerns the construct validity of the variables used in the research. Because each case study (1) used multiple sources of evidence for both intervening variables and dependent variables, (2) established a chain of evidence, and (3) performed a review with key informants from each site, the measures for the variables appear to have construct validity. Multiple sources of evidence used in two out of the three case studies showed consistency with predicted results.

The third explanation concerns internal validity. The direction of the changes in the variables fit the predicted pattern in each of the within-case analyses of the evidence collected. Pattern-matching logic applied to all three cases suggests that this research has internal validity, albeit not as strong as the internal validity verified using traditional inferencing and statistical techniques.

Also, rival explanations from other moderating variables were examined during data collection. The following rival explanations were investigated:

a) major changes in primary tasks

b) changes in the pay system

c) promotions

d) training programs

e) involvement in a human resource intervention (teamwork, job enrichment programs or quality circles)

f) transfers

g) changes in the structure of the department or the organization

h) changes in supervision or superiors

i) any other major changes noted by the employee.

The following rival explanations were observed and recorded but not included in the questionnaires:

a) Changes in the operating system, computers, or any hardware and software not related to the client/server implemented

b) Changes in the degree of formalization of the organizational structure.

Any one of these rival explanations could have affected the intervening and dependent variables. For example, if there was a major change in the primary tasks performed by the employees of the organization, the frequency of mutual direct contacts, the time taken to perform the tasks, and any of the other dependent variables would have been affected, depending on the new tasks performed. For that reason, the period between pre- and post-implementation data collection was limited to five months in order to reduce the possibility that any change might take place.

None of these explanations occurred at any of the three sites studied. The only major change was a change in the assistant accountant employed at InfoCom (third case study). The post-implementation interview was administered to a new assistant accountant who had started work after the old assistant accountant left the company. The new assistant accountant performed the same set of tasks performed by the previous assistant accountant.

A possible explanation for the unfavorable change in the business process is the lack of fit between the technology and the task it was supposed to support. This lack of fit could explain the lack of reduction in uncertainty and the lack of improvements in the performance of the individuals involved in the business process.

Conclusion

This chapter analyzes the evidence collected from the three case studies. Because the small sample size prevents this study from using traditional sampling theory and statistical methods, pattern matching was used to draw conclusions for each case study. A within-case analysis of the three sites shows that the evidence collected fits the predicted results based on the research framework. Two out of the three case studies investigated show favorable changes in their business processes after the implementation of the client/server system. Based on pattern-matching logic and explanation-building techniques used for the case study, both favorable and unfavorable results could be explained by the implementation of the client/server system.

CHAPTER 5: LIST OF REFERENCES

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CHAPTER 6

CONCLUSIONS

The purpose of this chapter is to present a discussion of results from the research, the major conclusions, and the implications of this study. The chapter begins with a discussion of research findings and contributions of the study. This is followed by a discussion of the limitations of this study. The conclusions offers suggestions for further research concerning the role of client/server systems in business process reengineering.

Discussion of Research Results

The objective of this research is to describe the role of client/server systems in changing business processes. The research framework proposes that the use of client/server systems moderates the relation between managerial action and the changes that management hopes to accomplish within business processes. The research framework suggests that changes to business processes are accomplished by reducing uncertainty.

The level of uncertainty experienced by the business process becomes an intervening variable between managerial action and business process change. As explained by Baron and Kenny (1986), a variable functions as a mediator or intervening variable when: (1) variation in levels of the independent variable significantly account for

variations in the presumed mediator, (2) variations in the mediator significantly account for variations in the dependent variable, and (3) a previously significant relation between the dependent and independent variables is no longer significant when the mediator is absent. The research results from the three case studies examined show that managerial action is related to variations in uncertainty, and that changes in uncertainty are related to changes in the business process. The strength of both relations was found to be significant using pattern-matching techniques. The research results satisfy the first and second criteria for mediation. Traditional statistical inferencing techniques were not used in this study because of the small sample size. The research results neither supported nor disconfirmed the third criterion for mediation. Therefore, the research results partially support the proposition that managerial action affects business process change by reducing uncertainty.

The research results from all three case studies show that the presumed moderating variable, client/server use, is related to the *direction* of business process change. Two out of the three case studies resulted in favorable changes in uncertainty and business processes. One of the case studies showed unfavorable changes in uncertainty and business processes. The research was not able to show changes in the *strength* of the relationship between managerial action and business process change. As stated by Baron and Kenny (1986), a moderating variable is defined as a variable that affects the direction and/or strength of the relation between the independent and the dependent variables. Therefore, the research results partially support the proposition that client/server use moderates the relation between managerial action and business process change.

These results contradict Davenport's (1993) model that relates I/T initiatives directly with process change (Figure 1). The research findings support Markus and Robey's (1988) emergent perspective of information technology and organizations. The emergent perspective's view is that the relationship between I/T and organizations is a complex social interaction which may result in unpredictable uses and consequences of I/T. The research findings also support Mohr's (1982) process theory of organizational change. This theory is similar to Robey's (1981), Galbraith's (1977), and George and King's (1991) assertion that no single independent variable is sufficient for explaining organizational change.

The research findings show that both favorable and unfavorable changes may occur as a result of client/server use. In the second case study (Edible Oil Co.), the client/server system processed and kept information concerning the truck carriers, the company's customers, the times that the carriers arrived, how much time they took to load the oil, and how many pallets were checked out each time. The information collected and processed by the client/server system at the third case study (InfoCom Corp.) was information to accomplish the task of order entry and purchasing. In both case studies, the information was relevant to their respective business processes. The client/server system fit the tasks it was designed to support. Consequently, both companies experienced favorable changes to their business processes.

The information collected by the client/server system from the first case study (Electric Co.) was insufficient for the purpose of scheduling a maintenance crew.

Examples of relevant information for that purpose may include: (1) a list of equipment that needs maintenance, (2) a maintenance history of each piece of equipment, (3) the availability of the maintenance crew, (4) the schedule of other electrical distribution centers, and (4) the availability of replacement components. The client/server system processed only the first and second items. Perhaps if the client/server system had access to more information and made it available to more people, the business process might have experienced favorable changes.

Contribution to Theory

The research findings help explain the complex relationship between I/T and organizations and adds modestly to the amount of empirical research on I/T and organizational change. According to the research findings, I/T is one of the many variables that interact to produce sometimes conflicting results in apparently similar circumstances. This research has empirically shown, albeit not via traditional statistical analysis, the relationship between the implementation of I/T and business process reengineering. This research introduced new constructs and variables that could be used to measure the level of uncertainty experienced by the business process and changes in business processes. It employs network analysis techniques that are seldom used in information systems research, thereby adding to the existing set of methodologies for studying I/T and organizational change. This research also introduced centrality as a possible measure for use in future research. The next section discusses this research's contributions to practice.

Contributions to Practice

This research sheds light on how well U.S. businesses are using client/server technology to change business processes and sheds light on the I/T productivity paradox. From the three case studies, the research findings support Davenport's (1993) and Hammer and Champy's (1993) assertion that the lack of I/T productivity is due to the failure of U.S. businesses to take full advantage of I/T's capability to change the way work is performed. The key word here is "I/T's capability." The research findings show that managers cannot presume, without proper planning and design, that I/T's capabilities will be utilized. The research findings show that changes in business processes, and consequently, improvements in productivity, can occur when I/T is specifically utilized to reduce the level of uncertainty experienced by the organization.

As discussed by Brynjolfsson (1993), the shortfall of I/T productivity is due to both measurement problems and mismanagement by developers and users of I/T. This research introduces alternative measurement methods for productivity. For example, measures relating to the number of employees in sequential tasks and within the managerial hierarchy in the business process could be used to reflect on the effects of I/T in improving productivity. Also, productivity improvements from the reduction of slack resources and other resources required to support the path distance between the decision maker and the customer could be used to measure the effects of I/T productivity. This research supports Brynjolfsson's (1993) assertion that developers and users of I/T are as

much to blame for the lack of I/T productivity as the inability to measure productivity from I/T.

This research shows that client/server implementation can improve or worsen the business process. The result of the implementation depends, in part, on how well the organization utilizes the client/server system to reduce uncertainty. Proper utilization of information technology must involve careful planning of how the technology will function within the business process. This research suggests that I/T can result in (1) compressing sequential tasks across function, (2) compressing tasks vertically within the managerial hierarchy, (3) eliminating slack resources, (4) reducing the distance between the point of decision and the point of information or eliminating intermediaries, (5) reconfiguring sequential process to operate in parallel, and/or (6) linking parallel activities during the process. Managers should measure the success of their BPR efforts these outcomes in addition to economic and financial measures. Many of the advantages or disadvantages of implementing client/server systems may not be apparent unless the manager studies the changes to the business process that may or may not occur as a result of that implementation.

In the third case study (InfoCom Corp.), the research results suggest that there may be a limit to the extent that an organization can reengineer itself, although this could be an artifact of the research methodology. Because of the small number of nodes in the network of the business process for InfoCom Corp., no changes in the number of employees in sequential and vertical tasks were observed at the business process level.

This "limit to reengineering" could serve as a benchmark or ratio that an organization could use to evaluate the success or failure of their business process reengineering efforts. This observation also suggests that certain business processes may not be significantly complex enough to warrant reengineering.

Limitations of the Research

The limitations of the present research fall into two major categories. First, because little is known about business process reengineering and client/server technology is in its formative stages, case study research was chosen as the research methodology. The small number of cases examined limited the possible ways in which the data could be analyzed. Second, many assumptions were made in the process of developing the research framework and research methodology.

Very little empirical research supports the assumption that uncertainty is the intervening or mediating variable in the research framework. This assumption is based on Galbraith's (1977) information processing model and Sviokla's (1989) study on the effects of expert systems on the information processing capacity of an organization. Baron and Kenny (1986) discuss the significance of moderating and mediating variables. They stress the importance of verifying the validity of these variables. Similarly, the research framework proposes client/server systems as a moderating variable. This assumption is based on Robey's (1981), George and King's (1992), and Markus and Robey's (1988) work. Because of the small sample size (three business processes), traditional inferencing and statistical techniques could not be used to show if uncertainty was the intervening

variable, or whether client/server use was the moderating variable. Although pattern matching techniques are recommended for drawing conclusions from this kind of research (Yin 1989; Eisenhardt 1989), the internal and external validity of this research is put into question.

This research attempted to show that the magnitude of the change in the database scope of the clients/server system affected the magnitude of change in business processes. To accomplish this objective, a quantitative measure (centrality) was used for database scope. Similarly, quantitative measures were used for the intervening variable (uncertainty) and the dependent variables. Due to the small sample size, this research employed pattern-matching techniques to draw conclusions. Pattern-matching techniques cannot be used for making any precise comparisons (Yin 1989). Therefore this research examined only the direction of change of the variables in the research framework, rather than their magnitudes. This limitation precludes the possibility of measuring the strength of those relationships.

This research chose database scope as a surrogate for client/server system use. Database scope was intended to represent enhanced access to data, services, and application -- a possible benefit of using client/server systems. This research did not make any attempt to define enhanced access to data, services, and applications. Consequently, the choice of database scope as its surrogate was arbitrary. The magnitude of database scope could not be used in the analysis of the data, due to the limited number of samples

examined. Additionally, there is no empirical research to support that enhanced access is related to the database scope of the client/server system.

The choice of measures for organizational uncertainty was based on Sviokla's (1989) studies with expert systems. This study assumes that the same measures can be used to measure uncertainty in a client/server environment. This assumption was not tested. Additionally, this study did not test the validity and reliability of the metrics used to measure uncertainty. The metrics were partially tested in a pilot study of a major consulting firm.

This research did not test the validity and reliability of the measures used for the dependent variables. For example, the measures used for compression of sequential tasks and compression of vertical tasks may be too simplistic. A change in the number of people in a sequential process may not represent a compression of sequential tasks, but only a change in the number of people involved in that sequence of tasks. This study assumes that each employee in the sequential or vertical process represents a single task, which may not be accurate. Notwithstanding all these limitations, other researchers can replicate this study and test its reliability using the case study protocol provided in chapter 4.

Suggestions for Further Research

The results from this study can be used for future research. First, this research can be replicated in any industry. As more samples are collected, the possibility of improving the validity and reliability of this study increases. With additional samples of business

processes, traditional inferencing and statistical techniques can be used to analyze the data. Also, the quantitative measures used in the study can represent magnitudes of change as opposed to just directions of change. Using both nonparametric or parametric techniques, the research can employ quasi-experimental designs that enable causal inferences to be made concerning the variables in the research.

Future research could include measures of productivity. Therefore, the researcher could make comparisons between client/server use, changes in business processes, and productivity of the organization. Field experiments could help increase external validity of this study. Laboratory experiments could better control effects from rival hypotheses and extraneous variables. Better control of variables and rival explanations improve the internal validity of the research and could significantly show whether client/server systems are moderating variables or otherwise.

The dependent variables used in this research are quantitative measures. Future research could relate these quantitative measures to monetary figures. For example, by matching the level of activity of each employee to their pay rate, managers could measure cost savings as a result of implementing the client/server systems. The cost savings would be significant if they increased managerial productivity. Future research in this area could provide managers and practitioners alike with benchmarks for client/server implementation.

CHAPTER 6: LIST OF REFERENCES

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APPENDIX A

ENABLING ROLE OF INFORMATION TECHNOLOGY (HAMMER AND CHAMPY 1993)

ENABLING ROLE OF INFORMATION TECHNOLOGY ACCORDING TO HAMMER AND CHAMPY (1993)

1. Database technology enables information to appear simultaneously in as many places as needed instead of only at one place at one time. Consequently, work involving this information need not be structured sequentially.
2. Expert systems technology can perform the work of many specialists. This system enables the introduction of a "case worker," who handles all steps in a process from beginning to end, eliminating handoffs, delays and errors.
3. Telecommunications technology allows businesses to reap the benefits of both centralization and decentralization.
4. Decision-support tools can make decision making part of everyone's job instead of just the manager's, job eliminating the high costs of hierarchical decision making.
5. Wireless data communications and portable computers enable field personnel to send and receive information wherever they are, eliminating the need for field offices and branches.
6. Interactive multimedia technology is able to give effective, customized contact with potential buyers, without the need for personal contact.
7. Automatic identification and tracking technology is able to inform customers in real time where their interests are, eliminating redundancy in personnel, equipment, and materials to cover the delays inherent in locating and rerouting things.
8. Advanced and affordable computing technology allows plans to be revised instantaneously instead of periodically.

APPENDIX B

ENABLING ROLE OF INFORMATION TECHNOLOGY (DAVENPORT 1993)

ENABLING ROLE OF INFORMATION TECHNOLOGY ACCORDING TO DAVENPORT (1993)

1. Automational -- Eliminating human labor from a process.
2. Informational -- Capturing process information for purposes of understanding.
3. Sequential -- Changing process sequence, or enabling parallelism.
4. Tracking -- Closely monitoring process status and objects.
5. Analytical -- Improving analysis of information and decision making.
6. Geographical -- Coordinating processes across distances.
7. Integrative -- Coordinating between tasks and processes.
8. Intellectual -- Capturing and distributing intellectual assets.
9. Disintermediating -- Eliminating intermediaries from a process.

APPENDIX C

RESEARCH INSTRUMENTS

Form A: Client/Server Survey

THE INFORMATION SYSTEMS RESEARCH CENTER
College of Business Administration
University of North Texas
P.O. Box 13677
Denton, TX 76203

Phone: (817) 565-3128
Fax: (817) 565-4317

Dr. Tom C. Richards
Professor of Business Computer Information Systems

Dear Manager/Project Leader/End User:

The Information Systems Research Center (ISRC) at the University of North Texas is conducting a scientific industry assessment of client/server technology. The ISRC is an industry funded center whose mission is to promote excellence in information technology (IT) practice and teaching, and to foster synergistic links between industry and the university.

Please take a few minutes to fill out this questionnaire and return it to us PREFERABLY via FAX (817-565-4317) or via mail using the enclosed envelope. If this questionnaire was handed to you, please hand this form back to your manager or the appointed researcher.
On completion of this study, participating companies will have answers to the following issues.

1. *What managers/users mean when they say "client/server".*
2. *The pervasiveness of client/server systems implementation (by industry type, firm size and IT budgets) specifically*
   a. *Type of applications on client/server systems*
   b. *Type of applications on mainframes*
   c. *Type of applications to be migrated to client/server systems*
   d. *Effective production client/server systems*
3. *The reasons why certain firms are not implementing client/servers.*
4. *Categories of client/server systems used in organizations and for what purpose.*
5. *Proportion of employees using each category of client/server systems.*
6. *Benefits from the implementation of client/server systems.*
7. *Effective client/server development systems.*
8. *Benefits from the implementation of client/server development tools.*
9. *Choice of strategies for migration to client/servers.*
10. *Critical issues concerning the implementation of client/server systems.*
11. *Breakdown of the costs of implementing CSS.*
12. *Effects of implementation of CSS on IT budgets.*
13. *The relationship between client/server implementation and business process redesign.*

This questionnaire is designed for managers/project leaders/users of information technology. The purpose of this survey is to get an accurate reading of the state of the client/server industry, at all levels of the organization and in each functional department. The results of this survey will yield valuable information that will help managers, and users alike to plan and better manage this new IT resource. You may be assured that the responses to this questionnaire ARE STRICTLY CONFIDENTIAL.

Sincerely,

Tom C. Richards

Dr. Tom C. Richards
Professor, BCIS
University of North Texas

CLIENT/SERVER STUDY:FORM A
UNIVERSITY OF NORTH TEXAS
INFORMATION SYSTEMS RESEARCH CENTER

Please fill in the following (optional) information. This information will help us validate the results of the survey and assure that we will get to you the report once the data analysis is completed.

Name of respondent:_____ Phone Number:_____

Name of organization: _____ Address: _____

DEMOGRAPHICS: PLEASE ANSWER ALL QUESTIONS

1. What is the size of your company in terms of annual sales for 1994?
   - a. Don't know ☐
   - b. Under $10 million ☐
   - c. $10 to $24.9 million ☐
   - d. $25 to $99.9 million ☐
   - e. $100 to $499.9 million ☐
   - f. $500 million to $1 billion ☐
   - g. More than $1 billion ☐

2. What is the size of your IT/IS (Information Technology/ Information Systems) budget in 1993 and 1994?

	1993	1994
a. Don't know		☐
b. Under $49,999	☐	☐
c. $50,000 to $99,999	☐	☐
d. $100,000 to $999,999	☐	☐
e. $1 to $2.99 million	☐	☐
f. $3 to $9.99 million	☐	☐
g. $10 to $49.99 million	☐	☐
g. More than $50 million	☐	☐

3. Approximately how many people are employed AT YOUR SITE ONLY in 1993 and 1994?

	1993	1994
a. Less than 100	☐	☐
b. 100 to 250	☐	☐
c. 250 to 499	☐	☐
d. 500 to 999	☐	☐
e. 1,000 to 4,999	☐	☐
f. 5,000 to 9,999	☐	☐
g. More than 10,000	☐	☐

4. Which of this best describes your job function:
   - a. I/S Management ☐
   - b. Software Development Management ☐
   - c. Networking/Network Management ☐
   - d. Corporate/End-user Management ☐
   - e. Technical Services Management ☐
   - f. End-user ☐
   - g. Other (Please describe) ☐

_____

5. What type of industry describes your company? (Choose one)
   - a. Agricultural/Mining/Construction ☐
   - b. Manufacturing of Computers and Communications ☐
   - c. Other manufacturing ☐
   - d. Transportation/Utilities ☐
   - e. VARs/Distributors - Computers and Communications ☐
   - f. Wholesale/Retail trade ☐
   - g. Finance/Banking Trade/ Insurance/Real Estate ☐
   - h. Business/Professional Services/ Consulting ☐
   - i. Health care ☐
   - j. Education ☐
   - k. Government ☐
   - l. Other (Please describe) ☐

_____

6. Is your site currently undertaking business process reengineering (BPR)? **BPR is defined as the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in performance.** Downsizing or restructuring is NOT BPR.
   - a. Yes, my site HAS UNDERGONE business process reengineering recently ☐
   - b. Yes, my site IS UNDERGOING business process reengineering ☐
   - c. No, my site is not undergoing business process reengineering ☐

7. If your site HAS UNDERGONE BPR, which process has successfully been reengineered? If your site IS UNDERGOING BPR which sites are being reengineered? (Check all that apply)

	Succesfull BPR	Undergoing BPR
a. Research and Development (R&D)	☐	☐
b. Engineering and design (including systems analysis and design)	☐	☐
c. Manufacturing	☐	☐
d. Logistical processes (e.g procurement and delivery)	☐	☐
e. Marketing Processes	☐	☐
f. Service processes (e.g. after sale services)	☐	☐
g. Other processes (please specify)	☐	☐

_____

8. Is your organization DOWNSIZING from mainframes to client/server systems? **DOWNSIZING is defined as the process of converting strategic applications to a distributed environment, using personal computers and local area networks.**

   a. Yes, my site is undergoing downsizing ☐
   b. No, my site is NOT undergoing downsizing. ☐

The next question seeks to understand what YOU mean by CLIENT/SERVER COMPUTING.

9. Regardless of platform (UNIX, IBM, Hewlett-Packard, Apple, DEC, etc.), rate the following descriptions according to how they BEST match YOUR definition of CLIENT/SERVER COMPUTING **using a scale of 1 (Does not match) to 5 (Best Match)**

	Does Not Match		Don't Know		Best Match
a. Workstation to mainframe connectivity (remote access)	1	2	3	4	5
b. Distribution of business application logic among different machines (decentralized applications)	1	2	3	4	5
c. Easy access to workstation/ PC-based databases (centralized or distributed)	1	2	3	4	5
d. Workstation/PC access to mainframe databases (e.g. via gateways)	1	2	3	4	5
e. Interacting with existing mainframe applications using graphical-based applications/interfaces	1	2	3	4	5
f. Computing in a PC/ workstation-based environment instead of a mainframe-based environment	1	2	3	4	5
g. Open systems	1	2	3	4	5
h. Any service to the user anywhere!	1	2	3	4	5
i. Cooperative processing	1	2	3	4	5
j. Other (please specify)	1	2	3	4	5

_____

The following set of questions are designed to measure the pervasiveness of client/server systems AT YOUR SITE in your organization.

A client/server system is defined as:

A DISTRIBUTED SYSTEM that uses requests and replies between client processes and server processes to achieve application objectives

Any combination of hardware and software platforms (mainframe or PC; IBM, HP, DEC or UNIX) can qualify as CSS as long as they fit the above definition. Generally CSS applications can be categorized into six types according to function:

(1) Distributed File Systems
(2) Client/server database or distributed database
(3) Online (Distributed) Transaction Processing Systems
(4) End-user tools (this category includes front-ends and in-house developed applications to client/server databases, query and reporting Programs, Decision Support Systems/Executive Information Systems)
(5) Office Information Systems (includes Groupware and electronic imaging systems)
(6) Client/server with distributed objects(e.g. using CORBA)

Please answer ALL the following questions:

10. Which applications at your site are executing on client/ server systems **(CSS)** and which applications are executing on the mainframe (MF)? (Check all that apply)

	CSS	MF
a. Order processing (including reservation systems)	☐	☐
b. Financial accounting and billing systems	☐	☐
c. Daily inventory management	☐	☐

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	CSS	MF
d. Daily production management (includes MRP planning and capacity planning)	☐	☐
e. Management accounting systems and daily budgeting	☐	☐
f. Project planning and management	☐	☐
g. Work group support and communication systems (includes office systems)	☐	☐
h. Marketing Information Systems (includes marketing intelligence, sales management, market forecasting and product pricing)	☐	☐
i. Strategic Budget Analysis, planning and preparation	☐	☐
j. Strategic Business Planning (includes use of DSS and EIS)	☐	☐
k. New product planning and research and development planning.	☐	☐
l. Systems Development Tools	☐	☐
m. Other (please specify)	☐	☐

_____

_____

11. Are any of these applications in the process of being migrated to client/server systems from centralized mainframe/mid-sized systems? (Check all that apply)

a. None. No applications at my site are being ported to client/server ☐

b. Order processing (including reservation systems) ☐

c. Financial accounting and billing systems ☐

d. Daily inventory management ☐

e. Daily production management (includes MRP, cash and capacity planning) ☐

f. Management accounting systems and daily budgeting ☐

g. Project planning and management ☐

h. Work group support and communication systems (includes office systems) ☐

i. Marketing Information Systems (includes marketing intelligence, sales management, market forecasting, and product pricing) ☐

j. Strategic Budget Analysis, planning and preparation ☐

k. Strategic Business Planning includes use of DSS and EIS) ☐

l. New product planning and research and development planning. ☐

m. Systems Development Tools ☐

n. Other (please specify) ☐

_____

_____

12. If YOU HAVE NOT YET IMPLEMENTED any client/server systems, which of the following reasons influenced your decision?

	Strongly Agree	Agree	Disagree	Strongly Disagree
N/A Not Applicable ☐				
a. Cost	SA	A	D	SD
b. Budget restrictions	SA	A	D	SD
c. Connectivity problems	SA	A	D	SD
d. Currently do not see the need	SA	A	D	SD
e. Lack of client/server applications	SA	A	D	SD
f. Lack of expertise for maintaining the CSS	SA	A	D	SD
g. Too much time to implement	SA	A	D	SD
h. Too difficult to implement	SA	A	D	SD
i. Immature standards	SA	A	D	SD
j. Immature technology	SA	A	D	SD
k. Security issues	SA	A	D	SD
l. Systems management issues	SA	A	D	SD
m. Other (please specify)	SA	A	D	SD

_____

_____

If you have NOT IMPLEMENTED or ARE NOT IN THE PROCESS OF IMPLEMENTING any client/ server system YOU HAVE COMPLETED THE QUESTIONNAIRE. Please mail the questionnaire back using the self-addressed stamped envelope supplied. Thank you for your time. The results of this survey will be mailed to you as soon as it is analyzed.

Answer the following questions ONLY if you have implemented client/server systems at your site or are in the process of doing so.

13. For each CLIENT/SERVER DATABASE OR DISTRIBUTED DATABASES your site currently uses, circle the proportion of employees that access that database

a. None or don't know ☐

b. Microsoft/ Sybase SQL Server 10 25 50 75 100%
c. Gupta SQLBase 10 25 50 75 100%
d. Oracle Server 10 25 50 75 100%
e. Ingres for OS/2 ..... 10 25 50 75 100%
f. IBM OS/2 Database Manager 10 25 50 75 100%
f. IBM DB2 for OS/2 ..... 10 25 50 75 100%
g. XDB-Server 10 25 50 75 100%
h. Informix 10 25 50 75 100%
i. Other (please specify) 10 25 50 75 100%

---

14. Which DATABASE ACCESS TOOL do you currently use? (Check ALL that apply)

a. None or don't know ☐
b. Gupta SQLHost/DB2 ☐
c. Oracle SQL*Connect ☐
d. INGRES/Gateway ☐
e. Micro Decisionware (Database Gateway) ... ☐
f. Information Builders (EDA/SQL) ☐
g. Sybase Open Server ☐
h. DEC Access Worker ☐
i. Other (please specify) ☐

---

15. For each UNIX-STYLE DISTRIBUTED FILE SYSTEM your site currently uses, circle the proportion of employees that access that distributed file system.

a. None or don't know ☐

b. Shared files or databases using Sun's NFS 10 25 50 75 100%
c. Shared files or databases using OSF's DCE (Please specify the product or type of application) 10 25 50 75 100%
d. Apple's Appletalk Filing System 10 25 50 75 100%
e. Other (please specify) 10 25 50 75 100%

---

16. For each ONLINE TRANSACTION PROCESSING (OLTP) system your site uses circle the proportion of employees that access that OLTP

a. None or don't know ☐

b. IBM's CICS for OS/2 ..... 10 25 50 75 100%
c. NCR's Top End 10 25 50 75 100%
d. Tandem's Guardian 10 25 50 75 100%
e. Transarc's Encina 10 25 50 75 100%
f. USLTuxedo 10 25 50 75 100%
g. Other (please specify) 10 25 50 75 100%

---

17. For each CLIENT/SERVER APPLICATION DEVELOPMENT TOOL your site uses, circle the proportion of employees that access that development tool

a. None or don't know ☐

b. Powerbuilder 10 25 50 75 100%
c. EASEL Workbench from Easel Corp. 10 25 50 75 100%
d. Andersen Foundation for Cooperative Processing 10 25 50 75 100%
e. SQLWindows from Gupta 10 25 50 75 100%
f. SQL Toolset from Sybase 10 25 50 75 100%
g. Advanced Revelation 10 25 50 75 100%
h. Clarion 10 25 50 75 100%
i. Pioneer Software's Q&E . 10 25 50 75 100%
j. Visual Basic 10 25 50 75 100%
k. Visual C++ 10 25 50 75 100%
l. Other (please specify) 10 25 50 75 100%

---

18. For each END-USER TOOL/OFFICE SYSTEM your site uses, circle the proportion of employees that access that tool

a. None or don't know ☐

b. Borland's Paradox SQL Link 10 25 50 75 100%
c. DataEase 10 25 50 75 100%

d.	Forest and Trees	10	25	50	75	100%
e.	Excel's Q&E	10	25	50	75	100%
f.	Gupta's Quest	10	25	50	75	100%
g.	Lotus Notes	10	25	50	75	100%
h.	SPC's InfoAlliance	10	25	50	75	100%
i.	Imaging systems	10	20	50	75	100%
j.	Other (please specify)	10	25	50	75	100%

---

19. For each IMAGE/DOCUMENT MANAGEMENT SYSTEM your site uses, circle the proportion of employees that access that tool

a. None or don't know ..... ☐

b.	FileNet	10	25	50	75	100%
c.	Viewstar	10	25	50	75	100%
d.	Sigma	10	25	50	75	100%
e.	IBM's Image Plus	10	25	50	75	100%
f.	SPC's InfoAlliance	10	25	50	75	100%
g.	Other (please specify)	10	25	50	75	100%

---

20. Are you using any client/servers with distributed objects(CORBA –Common Object Request Broker or other ORBs). If "Yes" specify proportion of employees using it and the name of the product

a. None or don't know ..... ☐

b.	Yes	10	25	50	75	100%

Please specify product if "Yes"

---

21. Rate the following BENEFITS OF CLIENT/SERVER SYSTEMS. (Circle one)
Strongly Agree (SA), Agree (A), Disagree (D), Strongly Disagree (SD).

		Strongly Agree	Agree	Disagree	Strongly Disagree
	SYSTEM PERFORMANCE?				
a.	I am experiencing improved response time from my client/server application	SA	A	D	SD
b.	I am able to offload processor-intensive applications to other machines	SA	A	D	SD
c.	I get reduced network traffic	SA	A	D	SD
d.	I get better performance for every dollar spent	SA	A	D	SD
	BETTER ACCESS TO DATA AND SERVICES?				
e.	I am able to access data previously not available	SA	A	D	SD
f.	I can access all applications and services from one workstation without logging in several times or using multiple passwords	SA	A	D	SD
g.	I am using a standard graphical user interface (GUI) for ALL applications regardless of environment.	SA	A	D	SD
h.	I can customize my GUIs	SA	A	D	SD
i.	I have processing autonomy -- I have complete control over the execution of applications and use of services	SA	A	D	SD
	MORE EFFECTIVE USE OF COMPUTING RESOURCES?				
j.	I am using computing resources (either/both mainframe and desktop) more effectively	SA	A	D	SD
k.	I have complete connectivity to other dissimilar environments	SA	A	D	SD
	ECONOMIC BENEFITS?				
l.	My organization has improved its cash flow as a result of changing over to client/server systems	SA	A	D	SD
m.	My organization has improved its return on investment as a result of changing over to client/server sytems	SA	A	D	SD
	PRODUCTIVITY?				
n.	I am generating more output (e.g. more sales, lines of code per unit of input.	SA	A	D	SD
o.	My organization is taking less time to deliver products/services	SA	A	D	SD
	FLEXIBILITY?				
p.	I can modify my computer configuration more easily	SA	A	D	SD
q.	I can modify my computer applications to suit business needs	SA	A	D	SD
	RELIABILITY				
r.	My applications are more reliable – I get less downtime	SA	A	D	SD

22. What costs have incurred as a result of implementing client/server systems? (Circle one)

	Strongly Agree	Agree	Disagree	Strongly Disagree
a. Increase in IS budget	SA	A	D	SD
b. Increased complexity in systems management	SA	A	D	SD
c. Connectivity problems	SA	A	D	SD
d. Difficulty in finding applications	SA	A	D	SD
e. Hidden support costs	SA	A	D	SD
f. Other (Please specify)	SA	A	D	SD

The last page of this survey contains a detailed COST ASSESSMENT FORM that will help you estimate the REAL COST of implementing your client/server system. If you decide to fill out this form, the data will be used to figure a norm for implementing client/server systems nationwide.

Answer Question 23 ONLY if you are using **CLIENT/SERVER APPLICATION DEVELOPMENT TOOLS, otherwise, skip to Question 24.**

23. Implementation of **CLIENT/SERVER APPLICATION DEVELOPMENT TOOLS** have resulted in (Circle one)

	Strongly Agree	Agree	Disagree	Strongly Disagree
a. Applications that are easier to debug	SA	A	D	SD
b. Applications that are easier to maintain	SA	A	D	SD

24. Which development techniques/tools were used to develop client/server systems? (Check all that apply)

- a. Client/server development tools ☐
- b. CASE Tools ☐
- c. Prototyping ☐
- d. System Life Cycle ☐
- e. Consultants ☐

25. Which implementation strategy was used to migrate applications to client/server systems? (Check all that apply if a combination was used)

- a. Parallel implementation – Both old and new system running simultaneously ☐
- b. Full cut-over – Specific cut-off date from old system to new system ☐
- c. Pilot – Implement client/server system on small scale first before expanding to larger system ☐
- d. Phased -- Implement client/server system in certain areas or department in the organization ☐
- e. Other (please specify) ☐

26. Which of these issues do you consider the most critical for client/server implementation? (Please rate them with 1 = Least critical and 5 = Most critical)

	Least Critical		Don't Know		Most Critical
a. Security	1	2	3	4	5
b. Reliability	1	2	3	4	5
c. Training	1	2	3	4	5
d. Resistance from end-users	1	2	3	4	5
e. Impact on job functions	1	2	3	4	5
f. Change in organizational culture	1	2	3	4	5
g. Distributed systems administration	1	2	3	4	5
h. Other (please specify)	1	2	3	4	5

THANK YOU FOR YOUR TIME AND PARTICIPATION. RESULTS WILL BE MAILED TO YOU AS SOON AS THE ANALYSIS OF THIS DATA IS COMPLETE.

Form B: Employee Questionnaire
Part A - Before Implementation

Employee Name: _____ Date: _____

Department: _____ Company: _____

PART A: TO BE FILLED OUT BEFORE THE IMPLEMENTATION OF CLIENT/SERVER SYSTEMS

1. Please state the primary task that you ARE PERFORMING in your organization BEFORE THE IMPLEMENTATION OF THE CLIENT/SERVER SYSTEM.

   a) _____

2. Please state any other important tasks that you ARE PERFORMING in your organization BEFORE THE IMPLEMENTATION OF THE CLIENT/SERVER SYSTEM (up to three only).

   a) _____

   b) _____

   c) _____

3. Do you have access to the client/server system? ☐ Yes ☐ No ☐ N/A

4. Please give the names of the people that you REQUIRE APPROVAL or NEED TO CONSULT to complete your task BEFORE THE IMPLEMENTATION OF THE CLIENT/SERVER SYSTEM (up to ten persons only). For each of these persons, state their work relationship with you (if they are part of your organized team, write "Team member") and write the AVERAGE number of times you consult them IN A WEEK.

	NAME	WORK RELATIONSHIP	NO. OF TIMES/WEEK
a)			
b)			
c)			
d)			
e)			
f)			
g)			
h)			

Form B: Employee Questionnaire
Part B - After Client/Server Implementation

Employee Name: _____ Date: _____

Department: _____ Company: _____

PART B: TO BE FILLED OUT AFTER THE IMPLEMENTATION OF CLIENT/SERVER SYSTEMS

1. Please state the primary task that you perform in your organization TODAY (AFTER the implementation of client/server systems).
   a) _____

2. Please state any other important tasks that you perform in your organization TODAY (up to three only).
   a) _____
   b) _____
   c) _____

3. Do you have access to the client/server system? ☐ Yes ☐ No

4. Please give the names of the people that you consult to complete your task TODAY (up to ten persons only). For each of these persons, state their work relationship with you (if they are part of your organized team, write "Team member") and write the AVERAGE number of times you consult them IN A WEEK.

	NAME	WORK RELATIONSHIP	NO. OF TIMES/WEEK
a)	_____	_____	_____
b)	_____	_____	_____
c)	_____	_____	_____
d)	_____	_____	_____
e)	_____	_____	_____
f)	_____	_____	_____
g)	_____	_____	_____
h)	_____	_____	_____

5. Please describe how the CLIENT/SERVER SYSTEM is helping you today

   _____

   _____

6. **PART B: EMPLOYEE QUESTIONNAIRE (CONT'D)**

Please circle if you were involved in any of the following items DURING the implementation of the client/server system.

a) A major change in your primary tasks
b) A change in your pay system
c) You were promoted
d) You went through a training program
e) You were involved in a new human resource program (teamwork, job enrichment programs or quality circles)
f) You were transferred to a new department
g) A major change in the structure of your department occurred
h) You have a new boss
i) Any other major change (please specify)

_____

Form C: Structured Interview with Managers
Part A: Before Implementation of the Client/Server System

Name of Manager: _____ Date: _____

Department: _____ Company: _____

1. Name the business process

   _____

2. Describe the product/service generated by the business process

   _____

3. Name the person(s) who is(are) in direct contact with the customer of the business process.

   _____ _____ _____

4. Name up to three person(s), closest to the customer, who are decision makers in the business process

   _____ _____ _____

5. Explain the relationships between the customer and the decision maker(s):

   _____

   _____

   _____

6. The number of multiple versions of the product/service generated by the business process

   _____

7. The amount of slack in the business process

   _____

8. Amount of manual work (i.e. not generated by the client/server system) that needs to be performed by each employee in the business process

   _____

9. The number of concurrent tasks in the business process

   _____

Form C: Structured Interview with Managers
Part B: After Implementation of the Client/Server System

Name of Manager: _____ Date: _____

Department: _____ Company: _____

1. Name the person(s) who is(are) in direct contact with the customer of the business process.

   _____ _____ _____

2. Name up to three person(s), closest to the customer, who are decision makers in the business process

   _____ _____ _____

3. Explain the relationships between the customer and the decision maker(s):

   _____

   _____

   _____

4. The number of multiple versions of the product/service generated by the business process

   _____

5. The amount of slack in the business process

   _____

6. Amount of manual work (i.e. not generated by the client/server system) that needs to be performed by each employee in the business process

   _____

7. The number of concurrent tasks in the business process

   _____

8. Do you believe (on a scale of 1 to 5) that the implementation of the client/server system has been a success? (Circle one)
   (1) Strongly Disagree (2) Disagree (3) Don't know (4) Agree (5) Strongly agree

Explanation of Items Used in the Instruments

Form C, Part "A": Structured Interview with Managers

Item 1 and Item 2
The purpose of these items is to clearly identify the business process and its boundaries to both the interviewee as well as to the interviewer. Once the boundaries are identified, the number of employees that needs to be interviewed can be determined.

Item 3
The purpose of this item is to enable the researcher to draw the customer into the sociogram.

Item 4
The purpose of this item is to extract the closeness of the customer to the decision maker in the business process and hence test Hypothesis 6. "Decision makers" in the business process are defined as the invididual in the business process that has the authority to decide the outcome of the business process. For example, in the case of a purchasing business process, the purchasing manager may have the only authority to approve a purchase. Certain purchasing departments delegate this authority to purchasing agents.

Item 5
Here the interviewee should explain briefly what takes place from the moment the customer requests service until that request is serviced or handled by the decision maker as defined in Item 4. The purpose of this item is to help the researcher build a mental picture of the business process.

Item 6
The number of multiple versions of the product/service refers to the different copies or categories of the same product or service. For example, CAD systems may be able to generate different alternative versions of a design. The data collected from this item are used to test Hypothesis 2.

Item 7
The amount of slack refers to extra resources available to the organization in handling uncertainty. Slack resources include keeping higher levels of inventory to prevent possibilities of stockouts, buying from many suppliers to prevent running out of supplies, and adding more time into the execution of the business process. The data collected from this item are used to test Hypothesis 7.

Item 8
The purpose of this item is to measure the level of performance required by the employees as measured by the manager of the business process. The level of performance refers to any manual work (e.g. cutting code) as opposed to systems-generated work (e.g., code generators). The data collected from this item are used to test Hypothesis 3.

Item 9
The data collected from this item are used to test Hypothesis 8. "Task" is defined as a subcomponent of the business process.

All the items above were repeated in the posttest questionnaire (Form C, Part B) except for items 1 and 2, for obvious reasons. Item 8 in Part B was included to test for the manager's acquiescence.

Form B, Part "A": Employee Questionnaire

Items 1 and 2
The purpose of these items is to determine the position of the employee in the sociogram and validate his or her involvement in the business process. Certain employees may be involved in more than one process.

Item 3
The purpose of this item is to determine the link (if any) the employee has with the current client/server implementation.

Item 4
This is the most important item on this questionnaire. Using the list of names and frequency of contacts given, the sociogram is built and the resulting matrices completed.

Item 5
This item records the opinion of the employee on the effectiveness of the client/server system and is used only in Form B, Part B.

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