Cognitive Science and Organizational Design:

A Case Study of Computer Conferencing

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Abstract

Many researchers have investigated and speculated about the link between information technology and organizational structure with very mixed results. This paper suggests that part of the reason for these mixed results is the coarseness of previous analyses of both technology and structure. The paper describes a new and much more detailed perspective for investigating this link. Using concepts of object-oriented programming from artificial intelligence, the information processing that occurs in organizations is characterized in terms of the kinds of messages people exchange and the ways they process those messages. The utility of this approach is demonstrated through the analysis of a case in which a reduction in levels of management is coupled with the introduction of a computer conferencing system. The detailed model developed for this case helps explain both macro-level data about the changes in the organizational structure, and micro-level data about individuals' use of the system.

Introduction

Since soon after the invention of computers, researchers have attempted to investigate the relationship between information technology (IT) and organizational structure. For instance, as long ago as in 1958, Leavitt and Whisler predicted that IT would lead to a dramatic reduction in numbers of middle managers. Recently there has been a flood of articles in the popular business press describing individual organizations where the introduction of IT seems to be associated with large organizational changes (Business Week, 1984, 1985). We are thus apparently beginning to see the effects of IT, but as yet we understand them only vaguely.

Our research involves a new perspective to investigate this link. The technique analyzes information processing in organizations in a much more detailed way than most previous work. Using concepts of object-oriented programming from artificial intelligence, we characterize the information processing that occurs in organizations in terms of the kinds of messages people exchange and the ways they process those messages. The models that can be developed using these object-oriented concepts have more of the precision and flavour of cognitive science theories than most previous models based on the information processing view of organizations.

We begin with a review of the literature on the impact of IT on organizations, from which we develop a new information processing approach to the problem. The utility of this technique is demonstrated through the analysis of a case, one in which a reduction in levels of management is coupled with the introduction of a computer conferencing system. The model developed in this case agrees with data about the changes in the

organizational structure, qualitative comments about changes in job roles and detailed analyses of message contents. We conclude by sketching possible future directions for research using our perspective.

Literature Review

Studies of IT and Organizational Structure

Many researchers have investigated the link between information technology and organizational structure. There seems to be a general expectation that IT can eliminate levels of management (Whisler, 1970), as originally predicted by Leavitt and Whisler (1958). The popular press is filled with anecdotes about firms that have reduced the number of their middle managers using IT (Business Week, 1984), but the empirical evidence is contradictory (Atwell and Rule, 1984). The results for the related question of centralization versus decentralization are similarly mixed, although centralization is seen somewhat more often (Robey, 1981; Rowe, 1984; Atwell and Rule, 1984; Carter, 1984; Pfeffer and Leblebici, 1977). Carter (1984) points out that studies conducted prior to 1970 favour centralization, and those after, decentralization, suggesting an increased familiarity with or improved computing technology. Pfeffer and Leblebici (1977) note that smaller firms are usually more centralized, and that IT may indirectly cause centralization by reducing the number of workers. Predictions of IT-induced unemployment, usually of clerical or production workers, have been pessimistic (Atwell and Rule, 1984), but these studies have a number of methodological problems that make firm conclusions difficult. The evidence regarding deskilling versus job enhancement is mixed, although "most workers surveyed regard the new technologies in a positive light" (Atwell and Rule, 1984: 1187). A number of studies have shown that IT can change work roles (Zuboff, 1983a; Foster and Flynn, 1984; Mohrman, 1982; Pfeffer, 1978; Pfeffer and Leblebici, 1977). Foster and Flynn (1984), for example, showed a change from hierarchically-based to competency-based roles in their study of the impact of a teleconferencing system. IT generally seems to increase the level of communication in organizations (Freeman, 1984; Sanders, Courtney and Loy, 1984; Foster and Flynn, 1984), although Robey (1981) found mixed results concerning the effect on lateral communications.

Limitations

Limited view of causality. These ambiguous conclusions seem to indicate that there are many contingent factors that have not been included in past analyses and demonstrate the weakness of current theories for analyzing such effects. One limitation of past approaches was pointed out by Robey (1983) and further discussed by Markus and Robey (1986). These authors note that organizations are designed to achieve certain goals and that these designs include the information systems as well as the formal organizational structure. Neither directly causes the other; rather, both are intended as solutions to perceived problems. Studies that view IT as a cause of change rather than one of many factors that enable change may therefore find inconsistent results. For example, Robey (1983) notes instances where a system was introduced after a reorganization. In these cases, IT clearly cannot be the cause of the change; however, there may still be a link between the two, which a less causal and more "interactionist" analysis might illuminate.

Scattered results. A second problem with the existing literature is that results are scattered. Although IT is likely to have multiple effects, many studies have focused on only a single aspect of organizational structure. With no theory predicting multiple effects and few comprehensive studies, it is difficult to gauge the total effect of IT on an organization.

Blunt measures. A final problem is the use of very blunt measures. IT (or information, uncertainty, or communication) is often viewed as a binary variable. At best, the total dollar investment in IT is measured, as if every dollar spent or every application had identical effects. Information and interaction are also grossly measured. As Freeman (1984: 205) notes, "structural studies of social networks typically ignore the content of the relations under examination; we act as if we expect to find some universal structural laws that can be applied equally well to friendship and to

corporate interlocks". Walker (1985), in a study of the communication patterns of a software firm, showed that there were different networks for technical and administrative information, again demonstrating that different kinds of information are treated differently.

Information processing theories

The solution to some of these problems is to examine more closely the link between IT and organizational structure. To do this, however, we need a theory in which the effects of IT are more easily interpretable. For this purpose, the information processing (IP) view of organizations (Galbraith, 1974, 1977; Tushman and Nadler, 1978) seems likely to be fruitful. Tushman and Nadler (1978: 292) outline three basic assumptions of IP theories: organizations must deal with work-related uncertainty; organizations can fruitfully be seen as information processing systems; and organizations can be viewed as composed of sets of groups or departments (which they refer to as subunits, and which we will call agents). In this view, organizational structure is the pattern and content of the information flowing between the agents and the way they process this information. The IP view has a major, although as yet mostly unexploited advantage, for investigating possible effects of IT, since it directly includes what IT can do: process information.

IP theories of organizations grew from the "Carnegie school" of decision making (March and Simon, 1958; Cyert and March, 1963), whose authors attempted to model how organizations make decisions. They noted such key factors as the limited rationality of human beings, which led them to consider explicitly the way people and organizations gather and process information. Their analysis, however, emphasized factors such as the steps involved in decision making, and did not focus much at all on the amount and kinds of communication between different agents. Galbraith (1974, 1977) expanded on their work, explicitly considering an organization's need to process information and reduce environmental uncertainty, and strategies by which it could achieve this goal. Tushman and Nadler (1978) hypothesized that different organizations face different levels of uncertainty and that an organization's effectiveness would depend on the fit between its information processing capacity and its environment. They discussed ways to improve this fit and noted that, "the information processing model holds promise as a tool for the problem of designing organizations" (Tushman and Nadler, 1978:300).

Limitations

The limitations of these theories are similar to those of previously discussed. The major problem is that the concepts discussed in these studies are still very aggregate. Galbraith and Tushman and Nadler treat information almost like a fluid, and uncertainty, its lack. An organization's structure then is like plumbing that directs the flow of information to where it is needed to reduce uncertainty. Such general factors are, as Galbraith notes, very difficult to measure, as it is unclear, for example, exactly what is and what is not information. Such simplifications are useful for general studies, but permit only very general conclusions. A more detailed analysis would attempt to characterize the content of the messages that comprise the flow of information and examine the processing that these messages require. The need for greater detail was anticipated by Galbraith, who noted, "to determine uncertainty, the required task information must be defined" (Galbraith, 1977: 37).

Toward More Precise Information Processing Models

Our perspective attempts to make such a finer analysis. One of the methods other information-processing-based disciplines use to gain insight into complex behaviours is to imagine how a computer could be programmed to reproduce them. In cognitive psychology, for example, computer models of learning or memory have been used to make theories about human information processing concrete and to generate further empirically testable hypotheses. The organizational models developed using our perspective are similar in flavour and purpose.

Like many earlier IP theories, we treat the organization as a collection of intercommunicating

agents. In addition to looking for the presence of information or uncertainty, however, we attempt to identify the content and purpose of the messages being exchanged and the actions that these messages trigger in the agents. Models developed using our technique are thus similar to a programme written in an object-oriented language (Goldberg and Robson, 1983; Stefik and Bobrow, 1986), since they specify the different classes of agents, the messages they understand, and the processing they do for each message. By modelling these features of an organization's information processing capability, we make concrete our assumptions about the organization, and can more quickly examine the effects of changes in its structure or in the technology used. In particular, these detailed models of communications and computation are especially useful for analyzing directly the changes that information technology may allow in the costs and capabilities for organizational information processing.

One criticism of this sort of analysis is that it is rather mechanistic. We model the organization simply, focusing on the pattern of communication and the types of messages sent. While these simplifications allow us to model computer systems quite accurately, they clearly do not address all aspects of human organizations. To include all features of organizations, however, would make our analysis hopelessly complicated. Furthermore, our simple theories do not have any particular advantage for analyzing issues such as power, opportunism or satisfaction. Although we do not consider such features unimportant, omitting them and concentrating on those features which seem easier to model makes it possible for us to derive unambiguous conclusions, which may still explain substantial parts of the behaviour of the organizations we study.

Example: The task assignment problem

To illustrate our perspective, we will present a specific model, the model of the task assignment problem developed by Malone and Smith (1984) and further expanded by Malone (1986). The model describes an organization in which tasks arise that must be assigned to "processors" (persons, machines or combinations) to be performed. The tasks may in tu be composed of subtasks, and different tasks subtasks may require processing by specific classes agent. For example, a manufacturing organizatic may receive orders for a product, the subparts of whi must be manufactured by one division, assembled another, and shipped by a third. An organization process tasks can have a number of possible structure four simple ones are shown in Figure 1. These fo organizations are simple forms of what in hum organizations would be called, respectively, functional hierarchy, a product hierarchy, decentralized market and a centralized market wi brokers.

These structures are clearly much simpler than tho of any real organizations. However, they serve analytic building blocks with which larger and mo complex organizations can be described. As in ma other sciences, study of such extremely simple forn may produce results that are more easily interpretab than those for realistic mixed forms, and which st offer insight into many real world situations.

Agents and messages

The agents in these organizations communicate sending each other messages. Again, for ease analysis we reduce complex behaviours to t minimum set of messages necessary to perform t function. Messages observed in real organization however, can often be interpreted in this framewor The simplest protocol is followed in the tw hierarchical organizations: a manager with a task be done chooses a subordinate who is able to do it, a assigns the task by sending it a *DoTask* messag When the subordinate finishes the task, it notifies t manager who assigned the task by sending *FinishedTask* message. Note that the agent to who the task was assigned may in turn decompose delegate it; for example, the middle managers in son organizations are assigned tasks, which they in tu assign to their own subordinates.

The difference between the two hierarchies is the level at which the task is decomposed. In the functional hierarchy, the general manager at the top of the hierarchy decomposes incoming tasks and assigns each subtask to the appropriate functional manager, who in turn assigns it to a subordinate. Each functional division is specialized to perform a single type of task. In the product hierarchy, the divisions are split along geographical or product lines rather than by function, and each division is therefore self-contained. Tasks arrive at the appropriate division and the manager of that division decomposes the task and assigns the subtask to the appropriate functional specialists in the division.

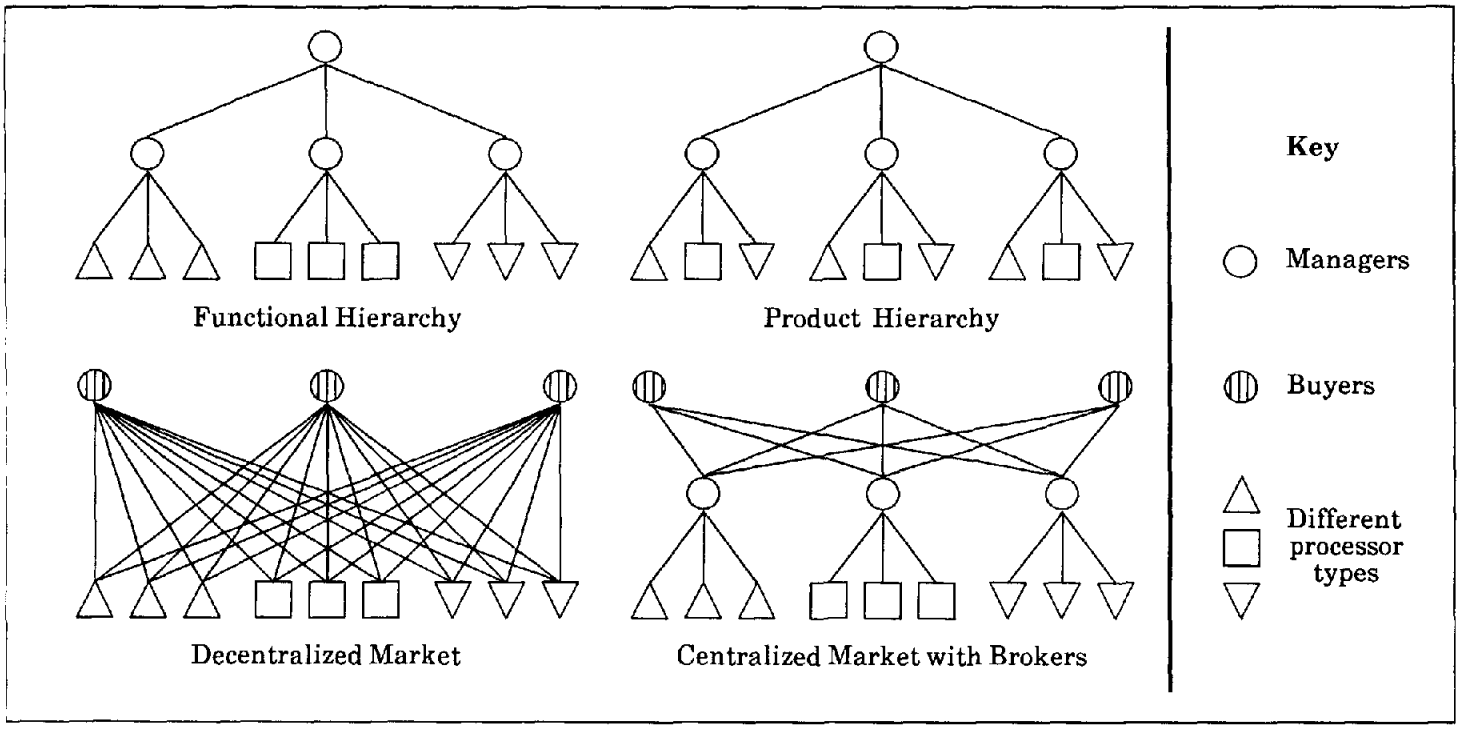
Markets add another set of messages to control a manager's choice of subordinate. A manager with a task to be done (a buyer) requests bids by broadcasting a *RequestForBids (RFB)* message; an agent who is interested in doing the task (a seller) then responds with a *Bid* message. The manager chooses (by some criteria) the best bid from those received, and assigns the task to that agent, using the protocol presented above. In a decentralized market, the manager will solicit bids from all of the agents in the market capable of doing the task. In a centralized market, the manager may simply contact a smaller number of brokers with "subordinates" capable of performing the task.

A summary of the different agent types, the messages they understand and the actions they take on receiving these messages is given in Table 1. It should be noted that some of these descriptions are incomplete. For example, *Seller* agents are described as understanding only *RFB* messages. These roles do not stand by themselves, but are rather used to supplement others. For example, combining the description of a *Seller* with that of a *Processor* gives an appropriate description for a *Processor* in a decentralized market; combining a *Seller* and a *Functional Manager*, the description for a *Broker* in a centralized market (see Table 2).

Comparing organizational forms

Each of these different organizational forms is capable of performing the tasks. They differ, however, in other properties, such as cost (the number of messages that must be exchanged to assign the task and the amount

Figure 1



Simple Organizational Forms
(Adapted from Figure 1, Malone and Smith, 1984: 7)

Table 1

Agent Type	Message	Action
Processor	*DoTask*	Perform the given task; when done, notify the assigning manager by sending a *FinishedTask* message
General Manager	*DoTask*	Decompose the task into subtasks and assign each task to an appropriate subordinate by sending a *DoTask* message.
	FinishedTask	Note that a subordinate has finished its subtask. If all the subtaks of a task have been finished, notify the assigning manager by sending a *FinishedTask* message.
Functional Manager	*DoTask*	Assign the task to an appropriate subordinate by sending a *DoTask* message.
	FinishedTask	Note that a subordinate has finished a task and notify the assigning manager by sending a *FinishedTask* message.
Seller	*RequestForBids*	If the task is one that this agent can do, send the buyer a *Bid* message; otherwise, do nothing.
Buyer	*Bid*	Add this bid to the set of bids received. If it was the final bid expected or if enough time has passed since the initial *RFB*, then evaluate and choose the best bid and assign the task using the given protocol.

Agents and Messages
for the Task Assignment Problem

Table 2

Base Agent Type	Supplement	Result
Processor	Seller	Processor in a decentralized market.
General Manager	Seller	Broker in a centralized market, although of a different kind than that shown. This type of agent would bid on and perform complete tasks, much like a firm in a competetive market.
	Buyer	Buyer in a decentralized or centralized market of the type shown.
	Seller and Buyer	Broker in a centralized market, although again of a different kind than that shown. This type of agent would bid on complete tasks, and then subcontract the subtasks, much like a prime contractor might.
Functional Manager	Seller	Broker in a centralized market of the type shown.
	Buyer	Buyer in a decentralized or centralized market. This type of manager would work in a hierarchical firm, but would contract out all tasks assigned.
	Seller and Buyer	Broker in a centralized market, although again of a different kind than that shown. This type of agent would bid on subtasks, which it would then subcontract. A temp-agency works in this way, centralizing a supply of free-lancers.

"Combination" Agents

of processing that must be done) and flexibility (the response of the organization to the possible failure of some agent). For example, assigning a task in a functional hierarchy is simple: the manager simply sends the task to the division responsible for that type of task. In a market, the manager must do more work to handle the many messages necessary to solicit and receive bids, process the bids and assign the task. If one of the mangers in the functional hierarchy fails, however, the entire organization will be disrupted, because no work can be done without that division. If a seller in a market fails, it will simply not bid on tasks, and none will be assigned to it. The additional cost of the market is balanced by its increased flexibility. Different organizations will make different tradeoffs between these costs, depending on their environment and their needs.

A queueing theory analysis of the different simple organizations is presented by Malone and Smith (1984) and Malone (1986). The total costs of the different organizational forms depend on a number of parameters, such as the cost of sending a message or of searching for a supplier. These parameters may be set to appropriate values to simulate existing organizations, or modified to identify the effects of the introduction of IT. For example, an electronic mail system may reduce the cost of internal communications; an electronic market, the cost of searching for a supplier (Malone, Benjamin and Yates, 1986). Either change might shift the tradeoff, making market-like organizations more desirable. As Malone (1986) shows, this model is consistent with two kinds of empirical observations, generalizations from previous work on organizational design and major changes in the structures of American businesses over the last century, such as are discussed by Chandler (1962).

Advantages

An integrative approach. Our theory has several advantages for study in the areas it addresses. First, it offers an integrated framework for studying organizational structure. In previous studies, different aspects of organizational structure had unrelated definitions, drawn from many different reference disciplines, and it was unclear how the different effects fit together. Our theory provides coherent definitions for many of these aspects, based on the flow of messages. The different sets of messages exchanged implement different *organizational processes.* The *structure* is the pattern of messages exchanged, that is, which agents are communicating and which messages they send. The set of messages to which a given agent responds, and the processing it therefore does, can be seen as that agent's *role.* With these definitions, we can begin to assess the link between IT and the whole structure of an organization.

Measurement. Since organizational structure is defined in terms of messages sent and received, it is also easier to measure these different aspects. The IP view provides a framework to guide the collection and interpretation of the necessary data. The view suggests the examination of the sources and users of data, the types of messages sent and received, and the actions agents take when they receive certain messages. Existing techniques, such as network analysis, may be used to reveal the pattern of communications. A protocol analysis of tasks can be done by examining the contents of a person's "in box" and watching as they read and act on the messages in it (*e.g.*, Malone *et al*, 1986). Sometimes messages sent using a computer system can be unobtrusively collected for later analysis. McKenney, Doherty and Sviokla (1986) performed such an analysis in a software firm, tracing the flow of messages and drawing flow charts to describe the processing involved in certain tasks.

Organizational simulations. Finally, the IP view suggests and facilitates the use of organizational simulations. Simulations have at least two advantages for research that make them desirable in this area. First, simulations require that assumptions be made explicit, making them easier to see and the results of changing them easier to test. Second, simulations make it possible to analyze systems that are too complex for analytic solution.

An Example Case

To test and further develop this perspective, we attempted to apply it to the analysis of a real organization. We examined an organizational change that took place in one part of a large electronics manufacturing firm, which we will refer to as the Electronic Manufacturing Firm (EMF)[1]. This case was selected because it appeared to be one in which an important organizational structure change was associated with the introduction of IT–in this case, a computer conferencing system.

Methodology

We developed a model of the organization in an iterative fashion, switching between data collection and model development. The construction of each tentative model revealed areas where our understanding of the situation was weak, thus focusing further investigations. We also attempted to test each model by looking for data that would disconfirm key assumptions or predictions. To conserve space only the final model will be presented and discussed.

The data for the model came from a variety of sources. Some data were collected in face-to-face and telephone interviews conducted with knowledgeable individuals in the organization ("key informants") between April 1985 and September 1986. This key informant method is limited, in that it relies heavily on retrospection. For instance, individuals may remember details incorrectly or give answers biased by new information or a desire to make a good impression. To reduce these effects, we interviewed a number of people in different parts of the organization and attempted to resolve any conflicting reports we received in follow up interviews.

We also collected more objective data to support our model. First, we observed our interviewees using the conferencing system. We also examined and classified several hundred messages stored in the system. Two of the interviewees reviewed drafts of this paper for accuracy and provided detailed information about the organizational structure before and after the change, including the approximate number and job grades of persons at each level of the organization.

[1] The names of the corporation, divisions and individuals have been changed to avoid revealing the identity of the organization studied.

History

The organization

The organization discussed in this paper is the Compensation and Benefits (C&B) organization of EMF. The C&B organization is a part of the Personnel Department that manages the compensation and benefits policy (*e.g.*, pay programmes) for the corporation. Because EMF is a decentralized company the C&B organization is geographically and administratively dispersed.

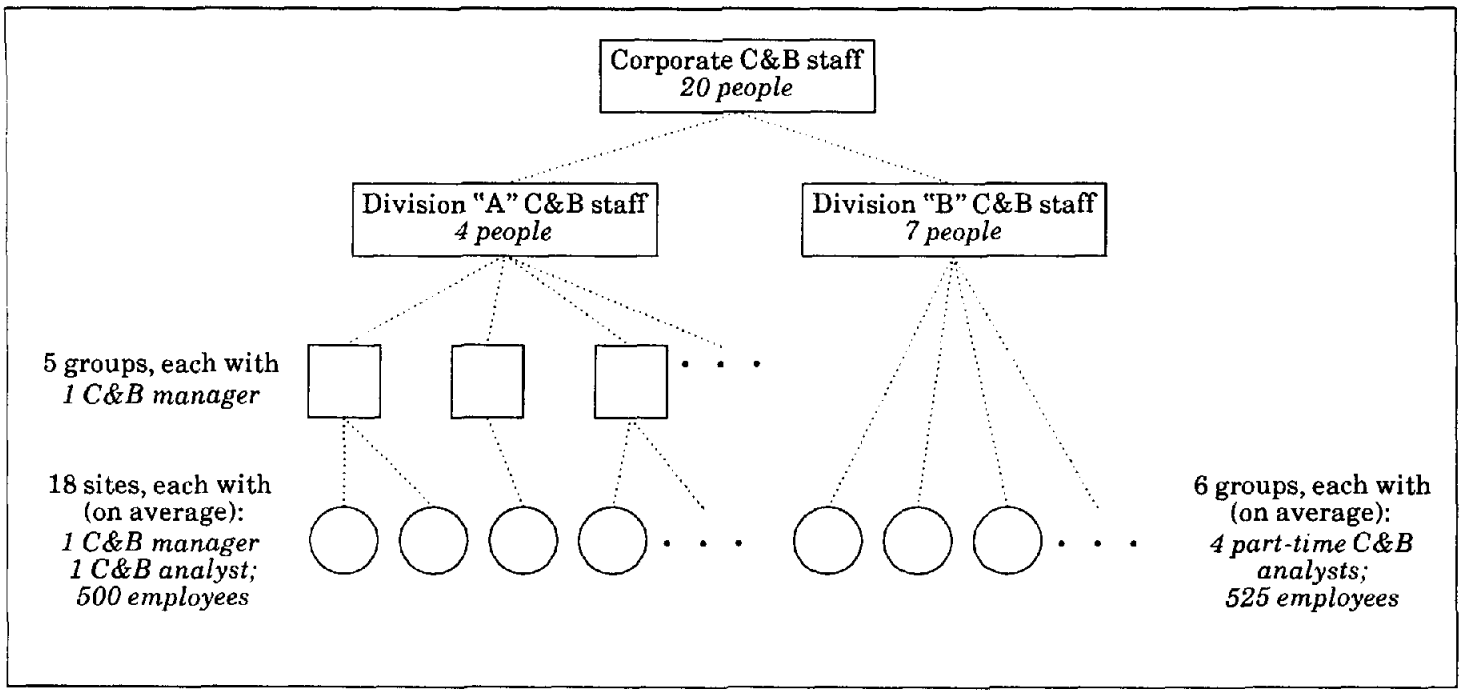
In the part of EMF we studied, there were originally two divisions (see Figure 2). The first, division "A" was composed of five groups, each with an average of four sites of 500 employees each (there were 18 sites in total). At each level of the hierarchy–corporate division, group and site–there were C&B managers who reported to the local personnel manager, and had a dotted-line relationship with other C&B personnel at different levels. In large sites, there might have been one or two C&B analysts who reported directly to the site C&B manager. The site managers were all at about the same job grade, while the group managers were at a higher level.

The second division, "B", had a more centralized structure. Each group had a few C&B analysts, but only one had a group C&B manager. In terms of job grade, however, most of the central staff members were about equal to the division "A" site managers.

The change

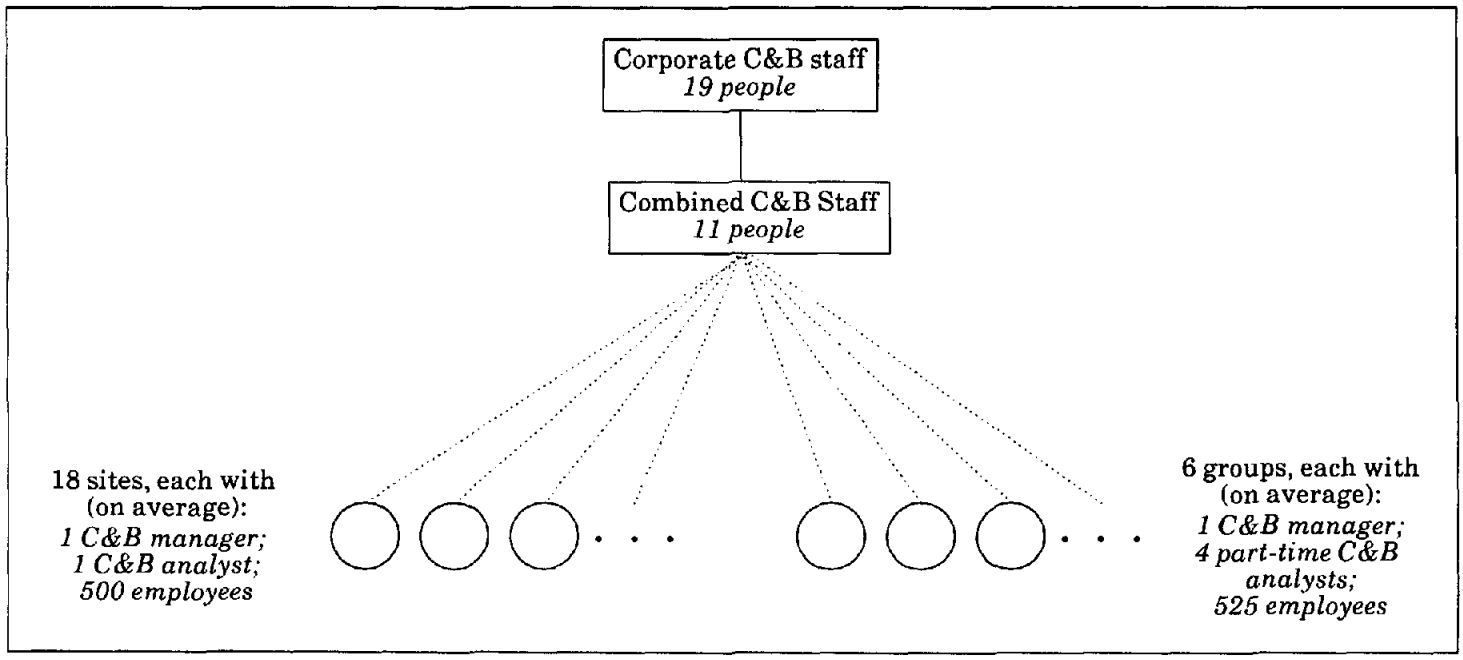
In the fall of 1982, these two divisions of EMF were merged. The C&B manager for the new division, John Miller, felt that there was "too much buffering between the policy makers at the corporate level and the policy implementors at the sites and that as a result the organization was not "generating enough new ideas". Furthermore, he felt that it was too expensive to maintain both the division C&B manager

Figure 2



Original organizational structure

Figure 3



Organizational structure after the merger and elimination of Division "A" group managers

and the group C&B managers, and that IT could be used to eliminate the middle level of management.

Miller therefore initiated a number of changes (see Figure 3). First, the old division staffs were merged and a new group formed to handle C&B for the new division. At this time, C&B managers were appointed for each of the groups in division "B". (Generally these were C&B analysts already in the group who had been informally performing this role.) It should be noted, however, that a "B" group is comparable in size to a single "A" site, and that the new "B" group managers were at the same job level as the "A" site managers. Second, with the agreement of the group personnel managers, the group level of C&B managers in division "A" was eliminated and the managers placed elsewhere in the company. Given the similarity between "A" sites and "B" groups, this left the entire organization with a fairly uniform structure. The transition to this new structure took place during the summer of 1983 and was completed by September, 1983.

The use of computer conferencing

In the original organization, the group managers coordinated the 18 division "A" sites, and helped formulate and distribute new policies and answer questions about existing ones. In the fall of 1983, after the elimination of the group managers, Miller, the head of the combined C&B division, arranged for the introduction of a computer conferencing system to serve some of these functions. It was intended that some communication between the different parts of the organization would take place via this system.

The manager responsible for the introduction of the system, John Baker, felt it had several advantages. First, since the information in the system was available to everyone in the organization, the corporate level staff did not have to answer the same questions repeatedly, as had been the case before. Second, the system sped up some communications and facilitated new interactions, both lateral and vertical. Baker also credited the system with increasing feedback from the site managers on new policies proposed by the corporate staff. A final hope was that sharing information would lead to better agreement on what the policies were.

An Explanatory Model

It is clear that no theory can capture all of the events associated with this change or explain every detail of what happened. Our goal is therefore more modest. We will simply use our modelling technique to show why the elimination of the group managers and the introduction of computer conferencing made sense in light of the problems described, and why this change was better than the other options considered. Note too that this case is one in which the organizational change happened before the introduction of IT, and both were designed to address a perceived problem with the existing organization. An advantage of our technique is that it can be used to explain the fit between the two, rather than the impact of one on the other.

Model development

A key step in the model building process is characterizing the function the organization performs. The function of the C&B organization was assumed to be solving any problems that arose by applying the policies created at the corporate level. This process might be called the policy development and application process (*e.g.*, see Barber, 1985). Different policies were assumed to be useful for solving different problems.

The model developed for the original organization is shown in Figure 4. The important paths that messages follow are the hierarchical dotted-line relationships. In this model, there are two kinds of information: problems and policies. Problems flow in at the bottom of the hierarchy, where the site C&B analysts see and attempt to solve them. Policies flow from the top, where they are created by the corporate and division C&B staffs. Each policy tells the C&B people how to deal with some of the problems. Problems also flow from the site analysts up and correspond to requests for clarification of a policy or for help in solving the problem.

Agents and messages

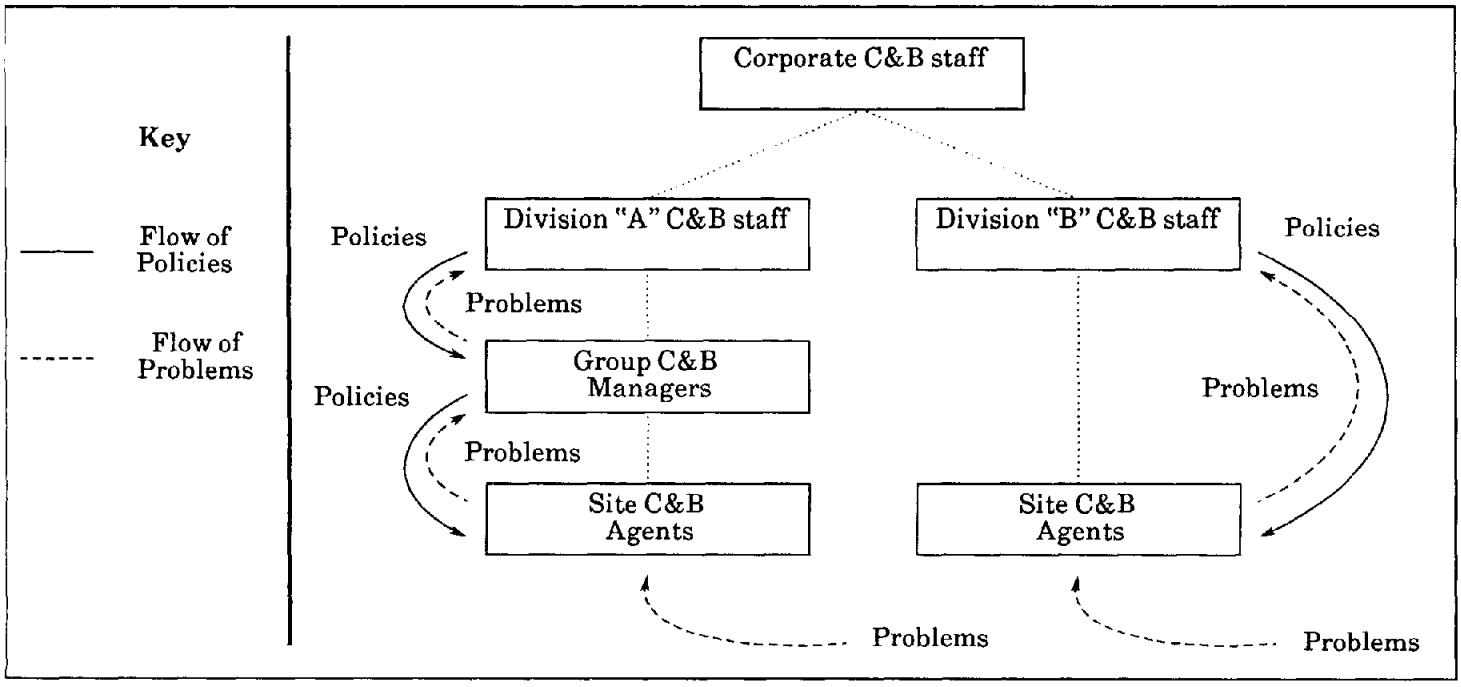
Based on job descriptions obtained in the interviews and presented above, a very simplified and somewhat abstract message protocol was developed to model the way members of the organization handle problems. The process starts with the receipt of a *Problem* message by a site agent. This agent is either a site analyst or manager. Normally, when a site agent gets a problem s/he looks for the policy that covers the situation. If s/he finds the policy, then s/he simply handles the problem. Otherwise, s/he resends the *Problem* message to the manager above him or her, asking for help. If a site or group manager is sent a *Problem* message that s/he knows how to solve, then s/he replies immediately by sending back an appropriate *Policy* message to the site manager, who then applies the policy; otherwise the process is repeated. The corporate C&B managers can always respond with a *Policy* message, since they know all the current policies and can create new ones when faced with new problems.

Part of the process of policy development involves consultations with agents in other parts of the organization. To model this process two additional messages, *RequestForComments* (*RFC*) and *Comment*, are used. The corporate C&B staff can send *RFC* messages, to which site managers can reply with *Comment* messages. Site managers may also treat *Policy* messages as implicit *RFCs* and send *Comments*. Note that we do not attempt to mimic the entire consultation process, but rather simply model the minimum communication that must take place. A summary of the agent types, the messages they understand, and the processing they do when receiving a message is given in Table 3. (To simplify the terminology, we use site analyst to refer to any site agent with no subordinates.)

Modelling computer conferencing

Our approach to modelling the use of the computer conferencing system is to simply change the pattern of linkages as shown in Figure 5. Computer conferencing can be used either to store information for later retrieval or to quickly disseminate it to individuals in the organization. We have chosen to emphasize the later function. In this model, everyone has an opportunity to see and respond to all messages. Note, however, that the basic function of the organization and the capabilities of the individual agents are

Figure 4



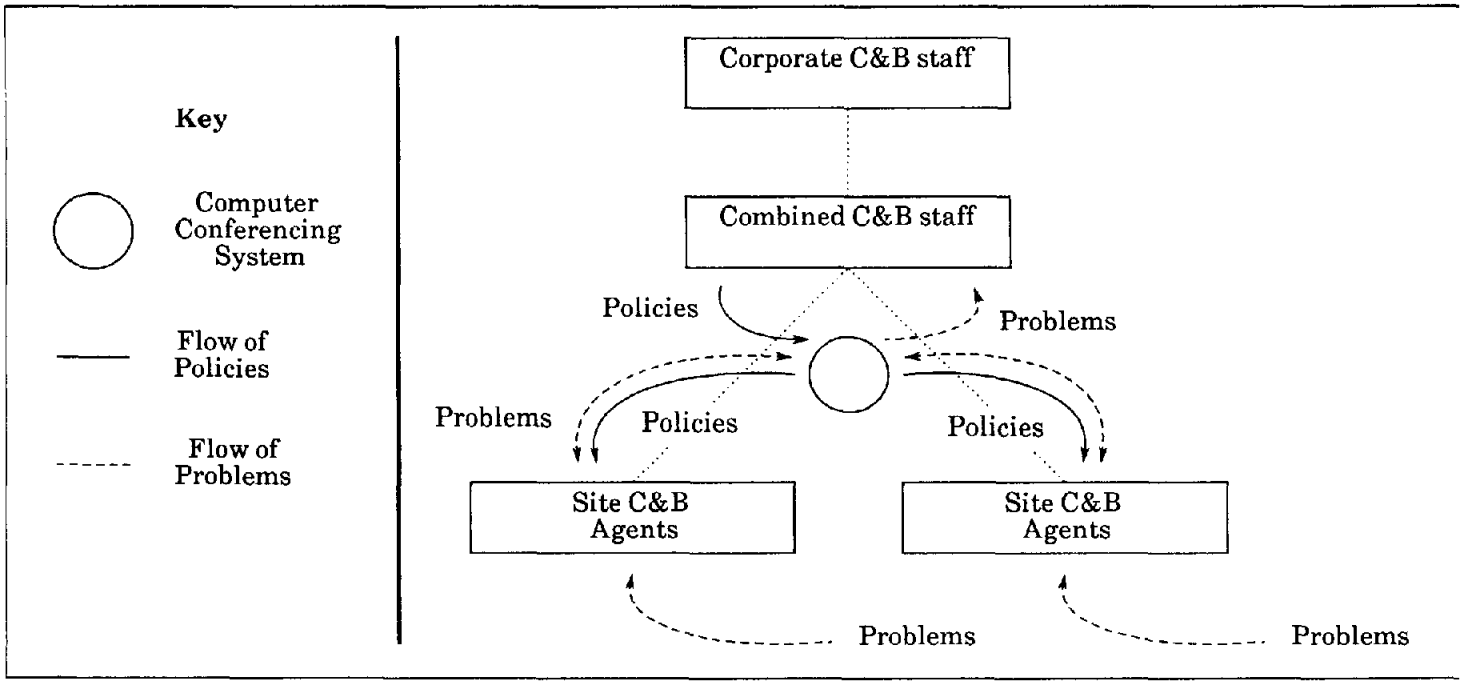
Model of the original organization

Table 3

Agent Type	Message	Action
Site C&B Analyst or Manager	*Problem*	Look up the appropriate policy for the problem. If it is found, use it to solve the problem. Otherwise, refer the problem to the next level by sending a *Problem* message.
	Policy	Note the new policy. If it can be used to solve a currently outstanding problem, then use it.
	RFC	Possibly return a *Comment* message.
Site or Group C&B Manger	*Problem*	Look up the appropriate policy for the problem. If it is found, then send the refering agent a *Policy* message. Otherwise, refer the problem to the next level by sending a *Problem* message.
	Policy	Note the new policy. If it can be used to solve a currently outstanding problem, then send the refering agent a *Policy* message.
	RFC	Possibly return a *Comment* message.
Corporate C&B Manager	*Problem*	Look up the appropriate policy for the problem. If it is found, then send the refering agent a *Policy* message. Otherwise, create a new policy to solve the problem, possibly asking for comments by sending an *RFC* message.
	Comment	Note the comment.

Agents and Messages
for the BCC Case Model

Figure 5



Model of the organization after the introduction of computer conferencing

unaltered–only the communication paths have been changed.

Content analysis of messages

One form of support for our model comes from a detailed analysis of a sample of messages from the conferencing system. From one of our interviewees, we obtained copies of 331 messages in four conferences, three complete ones containing a total of 202 messages about the development and implementation of new computer tools for salary management, and the most recent 129 messages (out of a total of about 450) in the general "catch-all" group. In order to protect the sensitive information discussed in some of the conferences, the three specialized conferences we analyzed contained few messages that related directly to the C&B "business" of the organization. They can, however, be interpreted as discussions of the implementation of a new policy, namely the new salary management system.

Based on the model and a preliminary analysis of the messages, we prepared descriptions (included in the appendix) of the four expected classes of messages, namely Policy, Problem, Request For Comments and Comment, as well as a category for other messages that used the broadcast capabilities of the system (such as announcements of meetings, job openings, Christmas greetings, and so forth). The messages were then read and classified by five graduate students in management, none of whom were aware of our hypotheses. Since coding messages was somewhat time-consuming, one coder read and classified every message; the others classified some of the messages as a check on the first. Each message was read by at least two coders and many were read by three. At least two coders agreed on the classification of 79% (261) of the messages, and only these messages are analyzed further.

The results of the classification, presented in Table 4, tend to support our model. Most of the messages fell into one of the four message types we expected. Of the remainder, most took advantage of the capability to broadcast to the entire organization.

We then used the messages in the four expected classes to test one hypothesis from the model about the direction of flow of different kinds of messages, namely:

> Most *Policy* and *RFC* messages will be sent by division C&B staff members.

Table 4

Policy	Problem	Request For Comment	Comment	Other Broadcast	Other
87 33%	47 18%	16 6%	41 16%	66 25%	4 2%

Number of messages in each category

Table 5

Organizational Location of Sender	Policy	Problem	Request For Comment	Comment	Total
Site	16 (40.5)	41 (21.9)	8 (7.5)	24 (19.1)	89
Corporate	71 (46.5)	6 (25.1)	8 (8.5)	32 (21.9)	102
Total	87	47	16	41	191

Message categories, broken down by organizational location of sender
Expected values are in parentheses

Most *Problem* and *Comment* messages will by sent by site C&B managers.

The number of each class of message, broken down by organizational location of sender, is shown in Table 5. The distribution is significantly different from that expected by chance ($\chi^2 = 61.43$, df = 3, $p \ll 0.005$) and examination of the table shows the deviations to be in the direction predicted by the hypothesis, with the exception of the non-significant difference for *RFC* messages.

Structural changes

Another support for this model comes from its ability to explain the observed structural changes by showing how the implemented changes address the perceived problems with the organization. We examine three such changes here.

Elimination of middle managers. As mentioned above, Miller, the manager largely responsible for the final change, had two complaints about the presence of group C&B managers in the organization: (1) maintaining the middle level of management in Division "A" was too expensive; (2) the group C&B managers "buffered" the division and corporate C&B staff from the problems being experienced by the site agents. It is clear that eliminating the group C&B managers will help the first problem by directly reducing the payroll costs for the organization. The second problem can be interpreted in the framework of the model by noting that in the original organization the division managers communicate only with the group managers and never directly with the site managers. This has two effects. First, the division managers never receive *Problem* messages directly from the site managers, but only indirectly through the group managers. Second, the division managers can exchange *RFC* and *Comment* messages only with the the group managers and not the sites, thus reducing the variety (and perhaps immediacy) of the comments received. Clearly, removing the group managers will make both of these types of communication possible and thus should reduce the sense of buffering.

Use of computer conferencing. After the divisions wer merged and the division "A" group manager eliminated, however, some new mechanism wa necessary to coordinate the 24 site level managers. I an interview, Miller, listed four alternatives h considered to solve this problem of a large "span c control":

- local peer communication (where one of the site managers would be responsible for coordinating the other sites in his or her group);
- dividing the division staff geographically (with each division staff member responsible for a different group of sites);
- large face-to-face meetings (where all site managers could hear the answers to each others' questions simultaneously); and
- use of computer conferencing (where again all site managers could see the answers to all questions).

In terms of structure, these changes reduce to a choi between some variant on the previous hierarchic structure and a market-like meeting structure, whe everyone is connected to everyone else in th organization. It seems clear from our analysis th maintaining a hierarchical structure will maintain th problem of lack of feedback to the corporate leve without affecting the ability of the corporate level poll the site managers. This suggests that a meetin like structure is preferable, eliminating the first tw alternatives considered. Computer conferencing w chosen as a technology to drive the organization change because it seems to have a lower cost for day-t day operations, although the interviews revealed th face-to-face meetings are also still held (biweek between the managers in adjacent levels; quarterly f others).

Increase in staff specialists. One surprising finding the case was that the total number of manage appears not to have gone down when the system w installed (see Table 6). One common prediction is th increased use of IT will lead to reduction in midd

Table 6

Organizational Level	Before		After	
	Job Grade 1	Job Grade 2	Job Grade 1	Job Grade 2
Site	18		24	
Group		5		
Division	4	3	2	5
Total	22	8	26	5

Number of staff members at each organizational level, before and after the reorganization

management. Such a reduction seems to have been a motive here, but, in fact, the total number of people did not go down. Instead, it seems that people were removed from group manager positions in division "A" and others of the same grade were added as staff specialists to the division staff, while the opposite happened in division "B". In total effect, there was a centralization, with more staff and decisions made higher up in the hierarchy. Accompanying this centralization was a specialization, since the staff added at the corporate level were responsible for specific programmes, unlike the generalist group managers they replaced. Lawrence and Lorsch (1967) note that such increased differentiation requires higher communication; similarly, Malone and Smith (1985) predicted that cheaper communication could lead to the use of functional rather than product or geographic hierarchies, as discussed above. The centralization and specialization seem to have been made possible by the reduction in communications cost and the broadcast capability offered by the system.

This finding suggests that technology-induced elimination of middle managers is actually a result of two causes: the introduction of some technology to make the elimination of the managers possible, and a resource constraint making such reductions important. In the absence of resource constraints, management resources that are no longer needed for mediating communication may be applied to other tasks such as formulating better policies. For instance, one manager we interviewed commented that, "the complexity of the work being accomplished has deepened and the quality has increased. . . I don't really know if some of those things would have been tackled a few years ago; I don't think they were".

Characteristics of system usage

Our model also exhibits a number of features that agree well with our observations and with comments made by our interviewees.

Job enlargement for site managers. Our model predicts a change in the role of site managers. Before the introduction of the computer conferencing system, site managers never saw *Problem* messages from their peers. Also because of the hierarchy, they would not see *RFCs* from the corporate or divisional C&B managers, and so would not participate in policy development. After the introduction of the conferencing system, however, site managers could receive both kinds of messages and could send *Policy* or *Comment* messages in reply, thus taking a more active role in the organization. Interviews with some of the division level managers indicated that such an upgrade in the status of site managers was in fact one of the goals of the organizational change, and one that they felt had been achieved.

System used for broadcasting messages, not information retrieval. The fact that the system was used primarily as a broadcast medium rather than as a data base was confirmed by a number of behavioural observations. First, most people in the organization subscribe to every conference they can, instead of only the ones in which they are currently interested, a fact brought up by the managers we interviewed and partially confirmed by examining the membership list for several conferences. Second, a division C&B manager reported that he checks who has read the messages in each conference and calls to remind those who are not caught up. We found some evidence that messages are reread from the system only in special cases. For example, when new employees joined the organization, they would be told to read the old messages in order to catch up. Also, at one point instructions for the use of a new system were made available on the system, but in

a separate file, not as a conference message. Finally, there seemed to be few provisions for searching the messages, and managers interviewed indicated that they rarely did that. These observations support our claim that the system was used primarily as a broadcast medium.

Conclusions

Using our technique we have been able to develop a model that incorporates observations at two levels. At the macro level, it offers an explanation for the structural changes that took place. At the micro level, it incorporates observed individual use of the conferencing system, reflected in the messages sent as well as the participants' impressions. We believe that this twofold support highlights the more inclusive nature of our perspective.

Our perspective seems likely to be further applicable in two distinct ways. First, it is useful, as demonstrated by the case above, for explaining and perhaps predicting the kinds of changes associated with the introduction of IT. As our review of the literature has shown, studies using only gross operationalizations of IT have only led to uninterpretable results. Studies based on a much more detailed understanding of the use of IT may led to more generalizable results. This suggests performing a number of cases studies of the sort presented here, and looking for common features.

A second use of this methodology was suggested by Tushman and Nadler (1978): design of organizations. A prior analysis of this type might be used to identify the organizational processes that can be effectively supported and the information systems and organizational structures that will be useful. A computer simulation of an organization, based on a model such as that developed above could be used by a designer to quickly and easily experiment with new organizational forms, predict the effects of different kinds of IT. A general design tool such as this could also be used to examine the properties of organizations that are not yet feasible, and thus explore the potential of future technologies.

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Appendix: Instructions for Codin Message categories

The code for each type of messages is given in *itali* after the description. Note that some messages ma have more than one type (*e.g.* a message giving a polic and asking about another policy). If so, please note a message types. Be CAREFUL to analyze the **conte** of the message rather than its form. For exampl "Would you send me documentation to help me wit System X..." is a *PROB* and not a *RFC*.

Policy *P*

A message outlining some policy or answering procedural question, including capabilities or use of system.

NOT a message giving a comment or opinion abo some policy or describing a problem with it.

For example:

"To login to System-X, type 'LOGO <user>' ..."

"Plan B will not update the database records..."

"Don't use the system on Fridays because..."

"To answer Fred's question, yes, we do enter tha data..."

Comment *Co*

A message giving a comment on or opinion about policy. Note that comment may be in reply to **Policie** as well as **RFCs**.

NOT a message outlining a policy or answering procedural question.

For example:

"We have reviewed the planning policy an suggest the following revisions..."

"I should clarify my view... The system shoul

verify..."
"To answer Jane's question, I agree, we should use a review board for..."

RFC *RFC*

A message asking for comments on a policy or system.

NOT a message asking for help implementing a policy.

For example:
"Please send a note with the following information..."
"Would someone tell me how you think we should handle .."
"Who's using review boards..."

Problem *Prob*

A message from a site person asking the staff for help with or for clarification of a policy.

NOT a message asking for comments on a policy or system.

For example:
"What is the contingency plan...?"
"What will happen to us under those rules?"
"Since when have we treated CPR teams that way?"

Other, classified *Other*

A message of one of the following types:

Personnel (*e.g.* "Please welcome Mary to the group" or "Goodbye");
Conference system related (*e.g.* branching a group or drawing attention to a new group or message);
Announcements of job openings;
Personal (*e.g.* "Merry Christmas");
Thank you's for some answer;
Meeting or meeting attendance announcements and questions (*e.g.* "Can we not meet on Sunday?"; "No, we have to meet then.");

Other, unclassified *?*

A message that can't otherwise be classified.

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