CENTRALIZED VS. DECENTRALIZED COMPUTING: ORGANIZATIONAL CONSIDERATIONS AND MANAGEMENT OPTIONS

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ABSTRACT

The long-standing debate over whether to centralize or decentralize computing is examined in terms of the fundamental organizational and economic factors at stake. The traditional debate is examined and found to focus predominantly on issues of efficiency vs. effectiveness, with solutions based on a rationalistic strategy of optimizing in this tradeoff. A more behavioralistic assessment suggests that the driving issues in the debate are the politics of organization and resources, centering on the issue of control. The economics of computing deployment decisions is presented as an important issue, but one that often serves as a field of argument that is based on more political concerns. The current situation facing managers of computing, given the advent of small and comparatively inexpensive computers, is examined in detail, and a set of management options for dealing with this persistent issue is presented.

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1. INTRODUCTION

Managers of computing in organizations have confronted decisions about centralizing or decentralizing computing ever since the computer proved to be more than just another piece of office equipment. The debate about whether or not to centralize computing has flourished for nearly twenty years in the community of information systems research and practice [17,29,55,56,101,107, 149]. The quest in the debate has been to determine the appropriate arrangement for the deployment of computing resources in organizations, given the needs of computing users and the desires of management to control the costs and uses of computing. The universally "appropriate" arrangement has never been found. Nevertheless, admonitions about how to deal with the question have continued to abound, usually prompted by technological changes that have altered the perceived efficiencies of different arrangements [3,12, 23,31,32].

As a result of such changes, managers have been faced with a continually changing terrain in which to make centralization vs. decentralization decisions. Managers are now being confronted with predictions about the "computing arrangement of the future" ranging from the conservative to the revolutionary: from the deployment of small, special-purpose computers in user departments, to networked distributed systems deployed throughout the organizations, and even to remote intelligent terminals in employees' homes enabling the workforce to "telecommute" instead of coming in to the office [12,14, 15,34,37,38,40,51,52,53,54,55,60,68,74,83,84,88,113,115,126]. Curiously, the tables have turned, and some have begun to argue that a computer is just another piece of office equipment, like a telephone or typewriter, inexpensive and available to all.

This paper first places the issue of centralization and decentralization in perspective, providing a working definition of the concepts and outlining the basic pros and cons of each. It then discusses the traditional debate over centralized vs. decentralized computing, focusing on the customary assessment of "tradeoffs" between efficiency and effectiveness in choosing which policy to follow. This is followed by a detailed examination of the problems with this traditional perspective, concentrating on the critical importance of political and organizational factors in the debate, and noting the ways in which simple economic analyses of the alternatives can result in misleading conclusions. This examination reveals that control is the most important issue in centralization/decentralization decisions, and that other issues must be seen in light of this fact. The paper concludes with an examination of the basic options for management in dealing with the centralization vs. decentralization issue, given the political and economic factors that underlie the debate.[2]

2. THE ISSUE IN PERSPECTIVE

2.1 A Working Definition

Most conceptualizations of centralization and decentralization rely on some concept of distance [57,58,120]: distance between plant locations; distance between different levels of organizational hierarchy or operations within an organization; the physical or organizational distance between where decisions are made and where they are enacted.[3] The centralization/decentralization issue generally takes one of three forms.

Centralization vs. decentralization of control concerns the locus of decision making activity in the organization [1,22,54,75,87,89,90,101,102,103,131,132,133,134,135]. Centralization implies the concentration of decision making power in a single person or small group; decentralization implies that decisions are made at various levels in the organizational heirarchy. Centralization vs. decentralization of physical location concerns where operations and responsibilities are located in physical space. Centralized physical location would have all facilities co-located; decentralizated location would spread facilities around the region or the county, or even internationally. Centralization vs. decentralization of function refers to the position of an activity or responsibility within the organization's structure. For example, centralized accounting and control would require all departments and units to report financial data to a single unit, whereas decentralization might establish a number of profit and loss centers with their own accounting activities and require that only aggregated data be passed up to the corporate headquarters.

2.2 Pros and Cons of the Alternatives

Centralization of control tends to preserve top management prerogatives in most decisions; decentralization of control allows lower-level managers discretion in choosing among decision options [22,23,35,87,89,102]. The former strategy can help insure continuity in organizational operations, but it can be disadvantageous because it increases the distance between the level where decisions are made and where they are put into action. If decisions are misguided due to poor top-level understanding of the problem, or are subverted due to poor enforcement at the lower levels, centralization can be disadvantageous. Decentralization of control helps force lower level managers to take responsibility for their decisions, thereby possibly improving their performance. It also encourages lower level managers to exploit innovative opportunities that help improve unit-level performance. Decentralization of control can create problems if lower-level managers are incompetent, are not appropriately held to account for their decisions, or if their decisions result in problems for other organization units or for higher management.

The main advantages of centralizing physical location result from capitalizing on economies of scale and preservation of organizational integrity in operations. Economies of scale arise from exploiting the full potential of technologies that cause output to increase more rapidly than costs. The costs of duplicating overhead and facilities can be avoided, and organizational protocols are easier to enforce. However, these advantages can be outweighed by other costs for organizational communications (including travel costs), transportation of raw materials and finished goods, and maintaining close ties to customers and clients. In special cases, such as military deployment or location of fire stations, the need for rapid response to unexpected situations also dictates the need for physical decentralization.

Centralizing organizational functions can help keep performance in line with organizational protocols and standards, smooth workflow on highly discrete tasks, constrain labor cost escalation by reducing the need for new hires, and allow close monitoring and adjustment of work activities to better correspond with overall organizational operations. Decentralization of functions is advantageous in cases where the functions being performed require close cooperation among other units, where the tasks being done require great worker discretion and less central guidance, or where regular interaction with members of other organizational units would require too much "commuting" by individuals, either from the centralized functional department to the other departments, or vice versa.

The basic questions of centralization and decentralization revolve around tailoring organizational arrangements to meet the constraints of organizational size, the nature of the technology involved in organizational operations, and the needs of organizational clients and customers [102]. These differences set the stage for all discussions of centralization and decentralization decisions. The objective of managers in choosing appropriate organizational arrangements is to choose the appropriate arrangement to match the organization's particular requirements to the alternatives available.

3. CENTRALIZATION VS. DECENTRALIZATION OF COMPUTING: THE TRADITIONAL DEBATE

The same considerations govern computing arrangements. Prevailing organizational structures will often dictate the broad outlines of computing systems arrangements [1,11,15,16,31,32,40,43,44,52,57,80,82,86,96,98, 104,112,113,117,124,127,138]. Organizations with centralized control and/or location of most activities are likely to have the same arrangements for computing. Yet, prevailing organizational arrangements do not always determine computing arrangements. Computing policies are often made without respect to other organizational practices, or even in efforts to change those practices [28,23,64,65,71,81,82,113,131,149]. The traditional debate over computing centralization and decentralization has often treated computing as a unique organizational resource in making policies about these alternatives.

The most common arguments in favor of centralizing computing have focused on the centralization of location and function: that is, whether to have computing facilities and/or service centralized or decentralized [6,7,31,32,43, 44,56,123,126,127]. To many managers, the basic advantages of consolidation could only be overcome when problems of geographic dispersal and increasing size of operations eventually forced decentralization. The advantages of hardware centralization seemed especially compelling given "Grosch's Law": that computing power could be obtained at a function equal to the square of the cost of the computer [46,47,48,49,96]. This law, borne out in subsequent tests [20,97,121,123], offered a powerful incentive to centralize facilities.

This usually meant not only complete centralization of machines, but of computing control and functions as well. Until the late 1970s, the authors of articles on computing centralization were nearly unanimous in the conclusion that, irrespective of its other impacts, centralization saves money [7,43,44,107,118,110,122,126,136,142].

Arguments favoring decentralization tended not to focus on economies, but on claims of improved computing service for users [31,32,43,44,57]. The question of use centered on control over use of the technology and physical access to computing facilities. A common admonition in the literature on location was that the department which controls computing would dominate its use and subordinate the users of other departments [6,7].[4] Users who could not get access to the technology would not use the technology. If the technology were decentralized, users would have access and would use it more. The closer the users' proximity to the control and location of the technology, and to the ability to directly interact with those who provide the service, the greater the use they would make of the technology. Similarly, decentralization would result in greater user satisfaction with computing. By giving users control or possession of the technology and computing staff, users would be able to utilize the technology more efficiently and effectively than under centralized conditions, thereby increasing their satisfaction [6,7,16,57].

The arguments over centralization and decentralization of computing have therefore tended to be cast as "tradeoff" debates, in which the organizational advantages of centralized control, uniform operations, and economies of scale have been pitted against user department needs for ready access to computing and opportunity for fitting computing capabilities to department requirements [31,32,57,58,142]. The tradeoff has often been reduced to "efficiency" vs. "effectiveness" [57,58]. The proponents of centralization have argued that centralized computing ensures efficiency, and permits effective service to users as long as good communications are maintained between the central computing service providers and the users. Centralization tends to be oriented toward top-down control: control of costs for computing, control of uses of computing, and in some cases control over information being processed. The proponents of decentralization have argued that properly developed, decentralized computing arrangements are profitable, even if somewhat more costly, because they improve the productivity of computer use by those who use the technology in the course of conducting the organization's business. Decentralization tends to be oriented toward bottom-up productivity improvement: improved exploitation of computing for departmental tasks and improved system design to meet user needs.

The high cost of computers caused most organizations to adopt relatively centralized computing policies, and proponents of decentralization usually had to fight on uphill battle. The advent of smaller, less expensive computers has changed the dynamics of the centralization vs. decentralization debate. User departments can now claim that decentralization is affordable, and maybe even less expensive than centralization. This change has stimulated the debate and created new challenges for managers who must decide what is to be done.

4. ORGANIZATIONAL CONSIDERATIONS IN THE DEBATE TODAY

If the new technologies do make decentralization affordable, why not decentralize? The answer is twofold. For one thing, it is not clear what "affordable" means. It is now possible to buy powerful computer processors for a fraction of what equivalent machines would have cost a decade ago. But computing requires more than computers, and the costs of computing entail more than just the procurement of processors. Second, computing has become increasingly important to organizational operations as applications have grown in size, complexity, and centrality to many facets of organizational life. Decentralization of computing often means decentralization of important organizational activities that perhaps should not be decentralized. Traditional arguments in the centralization vs. decentralization debate have undergone change, but the fundamental questions behind the debate are more complicated than ever. It is necessary, therefore, to look beyond the arguments of the traditional debate to the factors that make centralization vs. decentralization in computing systems such as a potent and persistent issue. This section examines two factors that appear to be of special importance: the politics of organization and resources; and the economic dynamics of deployment decisions.

4.1 The Politics of Organization and Resources

The politics of organization and resources refers to those formal and informal means by which decisions are made as to how different organizational units are treated in terms of resources, influence, and autonomy [4,22,26,28, 35,72,75,82,87,90,92,102,137,141]. Often the roles taken by specific organizational units dictate what share of organizational power and resources they receive, but this is not always the case. Sometimes there is considerable uncertainty about which roles various units should play in the "best" interests of the organization, and decisions about such roles must be resolved by competition and disagreement among the different interests involved.

4.1.1 <u>Consensus vs. divergence in goal setting</u>. The centralization vs. decentralization debate is fueled by disagreements. Are these disagreements over the means to accomplish goals, or over both the means and the goals? Much of the prescriptive management literature assumes that the ends are agreed on: that computing is a tool to be utilized in the "best" interests of the organization [e.g., 1,5,1,30,44,83,93,94,95,98,113,117,124]. According to this literature, the goal of computing policies is to provide for provision of computing services at the most effective level given costs, to maximize the organization's profitability and performance through use of computing, and to improve information flow throughout the organization to expedite operations and management. This goal-oriented view of computing sees the organization as a system of interrelated tasks, staffed by employees who are primarily concerned with maintaining and improving organizational performance [28,65,67]. According to this rationalistic view, computing systems are instruments (or in more elaborated settings, "environments") that, when properly managed, help the organization to meet its goals, adapt to its environment, and improve the performance of its employees.

Centralization/decentralization policy in this rationalistic context seeks to deploy computing resources in a manner that best facilitates productive use of computing and maintains managerial control over important organizational information. Computing is a tool that various organizational users need in order to do their jobs effectively; the task of management is to ensure that this tool is made available to users at the lowest cost given the appropriate users made of it. This does not necessarily mean computing must be provided as cheaply as possible. Factors such as geographical remoteness, specialized user needs, or high concentrations of demand for service might warrant costly solutions. The hallmark of a rationalistic policy for centralization/decentralization is the attempt to balance the efficiencies and effectiveness of various computing service arrangements given the justifiable needs of users. The design of policy concentrates on what "ought" to be done in line with the overall goals of the organization.

The focus on what "ought" to be done weakens the rationalistic approach to making computing policy in actual organizations by incorrectly assuming that the goals of various organizational actors will be coherent with the stated goals of organizational leadership [27,28,64,65,66,67,82]. In fact, there are important differences among factions within most large and complex organizations that suggest the presence of conflict and disagreement over organizational goals and the means for meeting them. A behavioralistic view of organizations suggests that individuals value their personal opinions and the needs of their own departments more highly than they do those of the organization at large.[5] The behavioralist view sees computing not as a discrete tool, but as a package consisting of both technologies and the intentions behind their use. Computing is used to further the goals of specific organizational actors (e.g., top management, financial controllers, data processing professionals) in ways that might or might not improve organizational performance or help meet organizational goals. Any disagreements over what the goals of the organization really are will preclude agreement on how best to use computing to meet them.

The behavioralist perspective has been conspicuously absent in the centralization/decentralization debate, at least as far as recommendations for policy are concerned. Disagreements over computing policies have been interpreted from a rationalistic perspective as being due to misunderstanding of either the facts or the goals. The rationalist solution to this problem is fact finding through conduct of studies (e.g., cost-benefit analysis) and goal setting or clarification through discussion (e.g. through user committees) to illuminate the appropriate course of action. It is seldom suggested that the facts are simply elusive, or that disagreements on goals are intractable. The practical objectives become to decide what the facts are, which is not always the same as finding them, and to decide whose goals will be accepted as the goals, which is not always the same as achieving goal congruence.

Despite the lack of centralization/decentralization studies embodying the behavioralist perspective, other studies of computing suggest that this perspective is a useful way to think about the issue [28,58,60,62,64,65,67, 70,72,82,106,116]. These studies indicate that the primary effects of computing on organizations arise first from the intentions behind computing use, and secondly, from the nature of the technology itself. Generally, computers are adopted and implemented in accordance with dominant organizational interests, and in support of those interests [28]. In small, narrowly-focused organizations, the dominant interests might include the interests of all the actors in the organization and computing could be applied to meet organization-wide goals. But such organizations are usually too small to be facing the centralization issue. Larger, more complex organizations usually have many and diverse social groupings, multiple organizational tasks and objectives, and more decentralized decisionmaking structures, which makes the presence of a single decisionmaking group that speaks for all interests unlikely [65]. Disagreements over how best to use computing are therefore endemic to such organizations.

In organizations large enough and complex enough to be facing problems deciding about whether to centralize or decentralize, one can expect continued conflict and disagreement in determination of computing policies. Students of organizational change suggest that in many complex organizations, polices are like a pendulum that swings back and forth between centralization and decentralization [75,89,90]. Resolution of disputes will not come simply from studying or discussing organizational goals. Facts and accepted organizational goals are important in making computing policies, and genuine consensus is sometimes possible, but the task of making policies for computing requires sensitivity to the motivations behind a wider array of organizational interests than those articulated by the dominant decisionmakers.

The use of a behavioralist perspective is useful in assessing the debates about centralization and decentralization, because it provides a perspective for interpreting where the desires to centralize or decentralize come from, and how they can be dealt with.

4.1.2. <u>The driving factors in the debate</u>. From the behavioralist perspective, there are nine organizational factors that drive the centralization/decentralization debate in the management of computing.

1. The need to provide computing capability to all organizational units that legitimately require such capability, in order to exploit the potential of the technology.

2. The need to contain the capital and operations costs in provision of computing services within the organization.

3. The need to ensure that special and sometimes idiosyncratic computing needs of user departments are satisfied.

4. The need to maintain organizational integrity in operations that are dependent on computing (i.e., avoid mismatches in operations among departments).

5. The need to ensure that information needs of management are met.
6. The need to ensure that computing services be provided in a reliable, professional, and technically competent manner.

7. The need to allow organizational units sufficient autonomy in conduct of their tasks to optimize creativity and performance at the unit level.

8. The need among organizational units to preserve their autonomy, and if possible, to increase the importance and influence of their units within the larger organization.

9. The need, wherever possible, to make the work of employees enjoyable as well as productive, including providing the opportunity for employees to partake in the "entertainment value" of computing.[6]

Each of these can be viewed from a rationalist perspective, with the goals in formulation of policy being to balance each criterion against the others so as to optimize the overall result. The problem with such an approach is that the objective function itself is unclear. Depending on who one talks to, a different set of priorities for these considerations will emerge. Moreover, in some cases, the considerations contradict one another. For example, the need to maintain integrity in operations across the organization can conflict with the desires of organizational units for autonomy in how they conduct their affairs. The way in which these different factors interact can be seen in the following illustrative history, which briefly recounts the evolution of policies governing administrative data processing over the past two decades.[7] By keeping these factors in mind, the complexity and persistence of the centralization/decentralization debate becomes apparent, and the current situation can be seen as a continuation of this history.

4.1.3. <u>An illustrative history</u>. Computers were first applied to tasks that were easily rationalized and programmed. In most organizations these tasks were in the area of administrative data processing, such as payroll preparation and accounting which had well-developed procedures and large processing volumes. The finance/accounting unit usually performed these tasks, and therefore could justify the need for computing. This unit also usually had prior experience with mechanical automation of data processing through unit record machines. The location of digital computing in the finance/accounting unit was a logical step. Capital and operations costs could be managed through the existing decision processes within the department, and through the normal budgetary process whereby the department negotiated for its share of organizational resources. The finance/ accounting unit controlled the computing system and could tailor the system to meet its needs. This provided autonomy in computing uses and operations. The well established communications channels between finance/accounting and top management facilitated upward flow of important financial information. The finance/accounting unit's role as a staff function allowed it to justify increased organizational investments in computing on grounds that they would serve the "whole organization." The newness and mystique surrounding computers made the finance/accounting unit unique and special in the eyes of other organizational units and top management. Reports printed by computers carried authority that other reports did not, while the technical complexities of computing could be used to buffer the finance/accounting department from inquiries about specific reporting requirements the department imposed on other units.[8] The fact that the computer "made the requirement necessary" was a powerful argument.

This exclusive relationship between the finance/accounting unit and the computer did not last very long. Other organizational units began to see possible applications of the computer, and to explore the means for exploiting the technology. The fact that computers were large, stand-alone machines provided only two possibilities for getting computing service to new users: acquire more computers, or make new users use the services of the finance/accounting unit. This posed a dilemma. The high capital costs of computing and "Grosch's Law" suggested that other users should share the finance/accounting computer. The finance/accounting unit's experience with computing helped ensure that computing services would be provided in a competent manner. And the close ties between finance/accounting and top management ensured that top management interests would be served. However, sharing meant the new users would lose some departmental autonomy by placing their data processing tasks in the hands of another organizational unit. It had the disturbing result (in the eyes of other units) of providing the finance/accounting unit with a powerful rationale for increasing its own budget and staff, and thereby its power and influence in the organization. New users would have to follow the finance/accounting department's guidelines for use, and their jobs would generally receive lower priority. Finally, to the extent that use of computing was viewed as exciting and desirable, the finance/accounting department maintained an exclusive hold over whatever such benefits computing provided.

The response to this dilemma was usually formulated by top management. The high capital costs of computers required that procurement decisions typically be approved by top managers. New computing centers were established in organizations where geographical considerations required them, or when other units had sufficient organizational influence to overcome the centralist arguments of economies of scale and integrity in computing usages. But this happened only in those organizations that had dispersed sites and/or large and powerful subunits that could successfully defend having their own computer center. In most organizations the centralist arguments prevailed, usually on grounds of economies of scale. The computer center remained in the finance/accounting department, and procedures were set up to allow other users access to the computer for their needs.

Neither the centralized nor the decentralized strategy proved to be perfect. Where multiple centers were established, there arose criticism of "proliferation" of expensive computers and concerns about maintaining technically-competent computing operations and meeting the needs of top management for information. Costs for computing did indeed rise rapidly, partly due to growing applications of the technology, and partly due to the exploitation of the budgetary leverage computing provided to the departments that had their own computers.[9] The individual centers often pursued their own goals, sometimes without much attention to the objectives of top management. A professional cadre of data processing specialists emerged that was able to consolidate its power around its professional knowledge, buffering itself from demands by its clients and top management [27,28,72]. In some organizations top management recentralized computing to gain or regain control of the increasingly important and complicated data processing function. In other cases, control over computing tended to devolve to the decentralized facilities as part of a larger decentralization of organizational activity.

There were also problems with centralized installations located in the finance/accounting unit. Centralization helped top management to contain costs and retain control over the growth and use of the technology. But it also resulted in serious disagreements between the finance/accounting unit and new users that wished to use computing. New users found themselves increasingly dependent on an important resource that was controlled by a department that had little understanding of their needs, and little inclination to take their problems seriously. The finance/accounting unit was busy trying to get its own needs satisfied. The new users felt shut out of responsive service, and found it difficult to have their special needs met. They also began to discover (as did the finance/accounting users) that they were becoming increasingly dependent on the technical data processing specialists who worked for the finance/accounting unit.

These pressures often resulted in the creation of independent data processing departments, usually under direct control of top management. This reform was designed to preserve the benefits of centralization while reducing the inter-departmental disagreements about access to services. It also moved computing closer to top management, elevating the status of the data processing professionals. These professionals would run the computing service like a "business," providing high-quality services to all users while carefully managing the computing operation to achieve maximum efficiencies and effectiveness. To overcome problems of disagreements among user departments about priorities and quality of service, and to improve accountability of the service to top management, these independent data processing units often established managerial mechanisms to improve their performance as professional service providers. They developed detailed and structured needs assessment procedures, complete with cost-benefit analyses, to assess user requests for new systems or rewrites of old systems. They established "chargeout" policies to impose pseudo-market constraints on use of computing services. They trained managers and users in use of computing. They created user policy boards and steering committees to help determine organizational needs for computing and the means to meet them. In short, they made concerted efforts to find facts and establish consensus on goals, in keeping with the rationalist view of the world.[10]

In spite of these reforms, the countervailing pressures remained and in some cases intensified. The movement of data processing upward in the organizational hierarchy removed it even further from the operating needs of user departments. User departments lost even more autonomy in dealing with their data processing needs because the new data processing unit was directly under the control of top management. The establishment of an independent data processing unit made it difficult to negotiate favorable terms for service, since the independent unit was there to serve "all" users. In fact, the user departments that traditionally had made the heaviest demands on computing services, such as finance/accounting, became the most important "customers" of the new independent data processing departments. They were usually taken more seriously than smaller users, since they provided the bulk of the data processing department's business. But even the major users faced loss of autonomy in their operations, new inflexibility in exploiting the productivity-improving potential of the technology, and the denial of the opportunity to exploit the entertainment value of computing. The rise of the DP specialists to a position just below top management meant that even the major users had to acccept the standards of the data processing department. The independent data processing department succeeded in accommodating several of the major considerations in the centralization/decentralization debate, but it did not meet them all.

The era of dominance of the centralized, independent DP shop lasted from the early-1960s to the mid-1970s. During this time the traditional advantages of centralization prevailed, while the advent of timesharing and remote terminals and job entry/output sites provided users with more direct access to the computing resource. The dominance of this arranagement began to subside in the mid-1970s due to the introduction of new technology, especially the mini-computer, which provided somewhat less computing power than the large computer mainframe but at much lower price. This lowered the entry cost of computing. Minicomputers could do many of the smaller jobs then being done one the large mainframes. Their low price made them attractive to user departments that traditionally depended for service on the centralized computing installation. They could be bought in small pieces, which disaggregated the purchase of a computer. A number of small, incremental purchase decisions enabled the assembly of a computer system by obtaining individual purchase approvals at much lower levels in the organization hierarchy than those required for purchase of large and expensive mainframes. As long as these purchases were not questioned, the establishment of minicomputer operations in user departments could proceed.

In the late 1970's the commercial appearance of the microprocessor, brought about by use of integrated circuits, again cut the cost of basic computer equipment. By 1980 a computer system with an 8 bit processor, 48K main memory, a 5 megabyte hard disk drive, an operating system, a terminal, and a hard-copy printer could be purchased for less than $6,000. Expenditures this low are almost insignificant in the budgets of major departments in large organizations, making them easy to get approval for.

4.1.4 The current situation. These small and inexpensive computers have radically changed the centralization/decentralization debate. User departments can now obtain their own computing capability, in some cases without even the knowledge of top management or the central data processing department. When a department's desire to purchase its own small computer or computers becomes known, the department can argue that the cost is so small that no economic arguments in favor of centralization are meaningful. These new computers are "affordable." Citing numbers 1, 3, 7, 8, and 9 of the needs noted above as a guide, widespread use of small computers can provide highly individualistic service to all the departments needing computing, allow users to establish and maintain autonomy in their operations using their own equipment, and provide users with hands-on opportunity to enjoy computing use while improving departmental productivity. Concern for costs (need number 2) seems unwarranted because these small machines are so inexpensive and off-the-shelf software for mini and micro computers makes it possible to keep operations costs down.

Assuming for the moment these arguments are correct, there remain several problems. As the review of the evolution of data processing in organizations shows, the characteristics surrounding the considerations in the centralization/decentralization debate might change, but the considerations themselves do not. The deployment of many small computers throughout the organization raises concerns for three of these considerations. First, the use of computer systems by users not familiar with the broader requirements of system management might compromise the quality of computing activity in the organization (need 6). Many practices the centralized DP shops have learned over the years, often at considerable cost, will not be known to the new users of small systems. These include methods for forecasting system requirements and costs, development of backup and fail-safe procedures, adoption and enforcement of documentation and maintenance standards, and effective ways of dealing with vendors and suppliers. The small scale of individual installations might reduce the impact of problems in these areas, but the aggregate of such problems throughout the organization could be serious.

Second, allowing user departments carte blanche to establish their own small computing operations increases the likelihood of disintegration in inter-departmental operations (need 4). This is especially true if incompatible systems are adopted through which interdepartmental information must flow, but it applies even to situations where small systems are compatible with one another at the hardware and software levels. Computing entails more than hardware and software; it includes the whole package of procedures and protocols required for smooth use of the technology [28,59,66]. Unless these too are standardized throughout the organization, there arises the opportunity for serious mismatches from one department to another. The dilemma of deciding between organizational standardization and departmental autonomy persists.

Third, the devolvement of data processing activities to the departmental level can increase the difficulty of obtaining data for top management use (need 5). For years a major goal of the DP profession has been to enhance the provision of information to top-level decisionmakers. But this is difficult even with centralized operations. The problems are not so much in the technology, but in determining what information to provide and how to provide it. The adoption of differing departmental standards and protocols makes uniform collection of data for upward-reporting more difficult, while the imposition of organization-wide standards diminishes departmental autonomy.

There is no easy answer to the centralization/decentralization debate. The fundamental considerations in the debate continue to assert themselves regardless of the technology, simply because they contain internal contradictions. The issue is not so much where the computer processors are located, or how decisions are made to acquire them. Rather, the fundamental issue is control over computing: who does it, what they do with it, and how they do it. Control must reside someplace. It cannot be shared equally among different groups of different opinions. The basic question has never been as simple as "which way is best?" Usually the question is "who's way is it going to be?" The advent of small computers with low purchase prices does not change this. It merely rearranges the bases on which the various sides take their positions and construct their arguments.

The issues involved in centralization/decentralization decisions are deeply tied to organizational behavior, and the consequences of centralization/decentralization politics become increasingly important as organizational investments in and dependency on computers increase. It is likely, therefore, that the debate will either be flaring or smoldering beneath the surface waiting to flare again.

4.2 The Economic Dynamics of Deployment Decisions

The economics of different deployment arrangements is critical in the debate because economic opportunities or constraints are often the most extensively discussed criteria in the political process of deciding whether to centralize or decentralize. Changing economic conditions keep centralization/decentralization questions alive by altering the economic rationales behind either course of action. The declining cost of computers, for example, has altered the economic justifications that traditionally pointed to centralization as the prudent arrangement. As long as the economies inherent in different deployment strategies are undergoing change, there can be no permanent resolution to the centralization vs. decentralization question on economic grounds.

A detailed discussion of these factors sets the stage for coping with the centralization/decentralization debate in the era of changing computing technology and applications. As technology and applications change, the opportunities for exploitation of the potentials of computing change as well.

To understand the economic dynamics of computing as they relate to centralization/decentralization decisions, the issue can be structured in the terms of the costs and benefits of computing and how they interact.

4.2.1. Computing costs. The cost dynamics of computing have changed substantially over the past two decades. Nowhere has this change been more dramatic than in the relative costs of hardware and software in computing systems. Boehm [9,10] claims that in 1955 computer hardware costs dominated software costs 7:1, but by 1985 software costs are expected to dominate hardware costs 9:1. This is a dramatic reversal, with equally dramatic effects on perceptions about the costs of computing generally. The acquisition of computer hardware usually preceeds acquisition of software, so this shift has had the effect of reducing the entry costs of computing. Starting into computing activity by procuring computers has become comparatively less costly than successfully implementing computing systems that actually meet organizational needs. The important point in this change is the altered view of the costs of computing it has produced. Computing now appears to many decisionmakers as inexpensive, but a closer look reveals that this is not so.

There is little comprehensive research on the costs of computing, but what does exist suggests that computing costs are substantial and often higher than they are estimated to be [63][11]. Underestimates are common because there are many hidden costs of computing, such as computing-related staff costs hidden in user departments and therefore not accounted for in computing budgets [91], staff time of users and upper management who must deal with intrusions and disruptions arising from computing [77,78], and "lost" productivity due to users and others who spend their time "playing" with computing simply because they have a personal interest in the technology [67,116]. Such costs can rightly be attributed to many cross-departmental functions, but they are important in assessment of computing costs because they can be significant components of those costs.

Computing costs are not only high, but they appear to be going up [19,34,61,93,105]; a paradoxical situation given that the "information society" rhetoric is based in part on the decreasing costs of computers. There have been dramatic reductions in price/performance ratios for computer processor hardware, but the cost of computing as a task has been rising due to increasing costs of other major aspects of computing such as facilities, software procurement, software maintenance, data management, data communications, and computing management.

Computing costs are rising for four reasons. The first is growth in application. As computing use grows and the number of applications in operation increases, the demand for both technical and managerial people to develop these systems and maintain them grows as well. The growth of computing has kept well ahead of the supply rate of programmers, systems analysts, and managers skilled in data processing administration, bidding up the price of their labor. Such a condition will continue as long as the rapid growth of computing spurs need for new talent that is not offset by an increase in the supply and/or productivity of such labor.[12]

Second is increasing system maintenance costs. System maintenance has been estimated to consume most of programmer's and analyst's time [9,10,76]. Kommunedata in Denmark, which provides computing to all 276 municipalities and counties in the country, estimates that it devotes approximately 20 percent of system development manpower per year to maintenance of each system it develops [114]. Maintenance costs are high and getting higher. Boehm [9,10] estimates that by 1985, 70 percent of all software costs will be for maintenance. Estimates of defense department software maintenance costs run between $2.5 and $4 billion per year, and this cost is going up.[13] As the number of systems increases, so do the carrying costs of maintenance. Maintenance also requires high quality software documentation, which is expensive to produce [9,33,41,77]. Documentation is a low-priority task in most software environments. The high turnover rate among programmers means that those who design systems seldom stay around long enough to help maintain them through the system cycle. Large and complex systems are built by teams of programmers where no single analyst or programmer understands the whole system, so the task of maintaining them is often experimental, time consuming, and expensive.

A third factor is the growing complexity of systems, and the disruptions caused when they are implemented and when they malfunction [74,93]. Simple, routine applications (e.g., a billing program for an electric utility) are basically automated versions of previously manual operations. Their scale and complexity is relatively low. However, as efforts are made to "improve" on these systems by adding new features (e.g., providing customers with comparisons of this year's electricity use to last year's), they become less like the operations they replace. Their implementation comes to require considerably more preparation, training, and time, all of which are very expensive. Complex systems are more likely to malfunction than are less complex systems, and are more difficult to fix because of their interdependency in operation [62,67,116]. Most fixes are like "patches" sewn on the fabric of the system. Often, they do not solve the problem, but "work around" it. In complex systems, patches frequently generate new problems as they deal with old ones, and the new problems must be patched as well. Extensive patching will destroy the design integrity of the original system, and systems often must be completely rebuilt before their expected useful life is over [66,76,77,78].

A final factor is the growth of integrated systems that organizations depend on. Integration means the interconnection of different systems or subsystems to form larger systems, often accomplished by linking systems so one provides output that serves as input to another. There have been a few efforts to build integrated systems from the ground up, but they have not been successful [64,71]. Most system integration comes by linking together otherwise stand-alone applications. Integration makes systems more complicated, which increases system costs. It also requires successful and timely performance of organizational units that use the systems. Both the system and all its users must interact in a smooth coordinated manner to take advantage of integration. Unintegrated systems and the interactions among organizational units are usually coordinated through policies and protocols that allow for slippage along the boundaries. Delays and problems that arise in one system or unit can be taken care of within the system or unit before it is necessary to interact with other systems or units. This slippage can yield considerable efficiency because it encourages highly localized, concentrated, and effective efforts to mitigate the problems that inevitably arise. Integrated systems make organizational units more interdependent in real-time, so problems in one system or unit can literally stop progress in others simply by disruption of the process of interaction. Integration can increase interdependency, and if interdependency cannot be coordinated and maintained in real time, costs from disruption will rise.

In summary, the overall cost of computing appears to be rising rapidly as new systems are implemented, as the price of technical talent increases due to intense demand and short supply, as maintenance costs of existing systems mount, as the complexity of computing systems increases (thereby driving up development, maintenance, management and replacement costs), and as previously stand-alone automated tasks are linked together in complex, integrated systems. The only factors that might alter these cost dynamics are a dramatic increase in the productivity of technical specialists who build and maintain such systems (brought about through implementation of new methods and/or technologies), or a curtailment in the growth of computing application causing the demand for such resources to fall back in line with supply.

4.2.2. The question of benefits. Computing is used because it has demonstrable benefits. These benefits do not accrue across the board in computing applications, however. They are primarily concentrated in those applications of the technology that assist in conducting routine, well understood tasks [62,70,73]. Benefits predicted as the most significant economically--cost reductions and staff reductions--have not appeared as expected, and are now seldom promised in systems proposals [36]. Computing's primary benefits have been three: improved speed and accuracy for some tasks, creating an opportunity to avoid hiring new staff; qualitative improvements in operations (e.g., reduced error rates, more flexibility in reporting and data manipulation, a greater range of analyses available); and increased capabilities for performing structured but complex tasks (e.g., airline reservation systems).

Benefits from computing application to more complex and uncertain tasks such as management decision-making are more difficult to ascertain. Most claims that applications such as decision support systems "save money" weaken considerably on close examination because extensive development costs are usually excluded from the equation. Sophisticated systems for solving complex problems take a great deal more effort to develop than do simpler systems, and usually a lot longer time. This leaves more opportunity to omit significant costs from the "cost" side of the cost-benefit equation [63]. There is a propensity for measurable costs to outdistance measurable benefits, which is why "runaway costs" and "cost overruns" are familiar terms, while "runaway benefits" and "benefit overruns" are not. The learning costs that go into building successful systems are accrued by way of the cost overruns incurred in development of unsuccessful or marginally successful systems. Despite structured design and other techniques for "deliberately" producing successful systems, most development is a trial and error process. The failure rate in systems development is high, just as it was 15 years ago [19].

Economic benefits claimed for most systems are not based on the amount of money saved, but on the differences in the character of the tasks performed with computing that seem beneficial to the using organization.[14] Often, these benefits are intangible, particularly those dealing with "improved information." This problem is illustrated by experience with another information technology, the office photocopier. This technology has increased both the volume and velocity of paper flow. Presumably, this increase in paper flow is beneficial because of the information written on the paper. But what is the "benefit" of having copies of memos go personally to five people instead posting a copy in a central location where all can see it? Improvements in organizational information flow and communication are extremely hard to measure. Often, no one knows what the information flow or the quality of the communication was in the first place, and it is difficult to put a value on the change even if it can be firmly measured.

The economic benefits of computing systems tend to be demonstrated by the argument that computing must produce benefits because so many organizations use it.[15] This argument makes two critical assumptions: that the true costs, short-run and long, are known to the organization when it makes its decisions; and that estimates of the benefits it will receive are reasonable and not exaggerated. If these two assumptions are in error, outcomes can be drastically different from expectations. The adoption of computing systems does suggest that the adopters find benefits from computing, but not what kinds of benefits. Some adoption decisions are made on strict economic grounds, but most are influenced to some degree by other organizational and political factors (e.g., a department manager's strategy to become a computer user to build his budgetary claims, or simply the desire to have his own computer).

A final problem in assessing the benefits of computing across organizations rests in the choice of the applications evaluated. Successful systems demonstrate what is possible, but not what is likely to happen in most instances. Predicting industry-wide potential of computers based on experiences of a small number of highly talented organizations is unwise. One must look at what actually occurs in most organizations. Sophisticated applications and innovations in computing can be found in many organizations, but they appear thinly and sparsely across the population of organizations [59,70]. A given organization might have one or two significant and successful innovations, but the rest are either rather routine applications, or are "failed" examples of more ambitious efforts. The benefits of such innovations are often discussed in terms of their demonstrated potential in a few special cases, and not on their probable performance in wide deployment.

A summary of what is known about the benefits of computing in organizations yields seven findings: (1) Benefits seem to be difficult to pinpoint in strict, economic terms, although the fact that computing has been and continues to be heavily adopted and used suggests that organizations believe the benefits are there. (2) Most direct economic benefits, such as staff reductions and cost savings, do not seem to have materialized in most applications of computing to administrative data processing. (3) Indirect economic benefits, such as improved capabilities and cost avoidances or displacement, do seem to have accrued as a result of computerization of administrative data processing. (4) Most of the measurable economic benefits from computing appear to come from fairly routine applications (e.g., accounting, record keeping). (5) Economic benefits from advanced applications such as decision support systems and planning systems are more difficult to identify, especially in relation to their costs, although recent research suggests that they do accrue in some circumstances [36]. (6) Claims of economic benefit are usually made to justify proposed computing developments, but other organizational and political factors figure prominently in motivations to engage in computing. (7) Regardless of the potentials for computing benefits demonstrated by advanced user organizations, most organizations will take longer to realize such benefits if they in fact do so at all.

These findings do not suggest that computing is unbeneficial in economic terms. Rather, they imply that there are other kinds of benefits that play a role in organizational decisions about computing (benefits of political and personal nature for those involved), and that the hoped-for economic benefits of computing often systems do not accrue according to plan.

4.2.3. Costs, benefits, and the centralization question. This review of the costs and benefits of computing provides a base from which to analyze the likely effects of centralization/decentralization decisions on the economic dynamics of computing. The technological changes in computing hardware in recent years has spurred a movement toward decentralization, or at least toward greater proliferation of computing to outlying departments in organizations. It is useful now to ask what the effects of such decentralization might be in economic terms.

4.2.3.1 The dynamics of costs in computing. The experience of data processing in large organizations over the past two decades suggests that decentralization of computing entails organizational changes that are likely to prove costly for two primary reasons.

The first factor in increased computing costs from decentralization is the expansion of computing activity as users gain control of computing resources. If computing activities were only undertaken to improve efficiency and effectiveness, and only after it had been shown that such activities would in fact do so, this would not be a problem. But computing lures users for other reasons, not the least being its attractiveness as an exciting and potentially useful technology. Faith and delight in computing is a strong motivator for adoption, and often overcomes the need for "demonstrated benefits" in the decision to adopt [28,69,70,129]. This phenomenon is not new. It is evident from experience with other technologies that were initially relatively simple and practical solutions to problems, but that over time became important to their users in their own right. Technological advances in such fields as automobiles, photographic equipment, home entertainment equipment, household appliances, and medical technology have not only resulted in improved performance for cost. They have led to major increases in consumer expenditure in the application areas to which they are applied. As new capabilities emerge, so too the perceived "needs" of users increase.

This phenomenon seems likely to happen in the case of new, small computer systems. When a user department acquires a small system to take care of small departmental needs, the needs often begin to grow. As new and more enticing equipment becomes available, investments in the system begin to grow. Before long, the overall investment in computing has grown far beyond expectations. A case recently observed by the author illustrates this. A university's financial administrators were dissatisfied with the service they received from the campus computer center, and bought a fairly powerful minicomputer to do their own computing jobs. They hired a staff of ten to staff the enterprise. Within three years they had grown to two minicomputers, were buying a third, and had a computing staff of 40. The computer center they left had also grown bigger. These users had the best of intentions when they got their own computing system, but they did not know what the computer staff had learned over the years: that computing is a very expensive business, regardless of how inexpensive it looks at the front end. To actually accomplish what they wanted to do they had to continually increase their investment. And their investment was the University's investment. In very few cases does a computing installation, be it centralized or decentralized, get smaller and cheaper over time.

When control over computing procurement and systems development decisions devolves to users, individual departments might begin to build computing systems that do not necessarily meet the same investment criteria that purchases by the central data processing department must meet. Unwise investments can be made, sometimes without the knowledge of top executives. This came to light recently in a computer printer manufacturing company that was deliberating over whether to make a $300,000 investment in new equipment for the data processing center.[17] Someone suggested that the money might be better spent for microprocessors for users. A study revealed that user departments had already spent over $1 million on microcomputer and minicomputer equipment in the previous twelve months, without the knowledge of the data processing department. Had the organization instituted and maintained a strict centralization of acquisition control, it could have reviewed and guided these procurement decisions. But that would have entailed greater management costs for control.

The second major factor suggesting that decentralization of computing will increase computing costs arises from changes and disruptions in organizational operations that often accompany decentralization. Decentralization requires change, and change can be planned for. But unless the move to decentralize is made coherently throughout the organization there cannot be a comprehensive plan. In many organizations decentralization is happening by default as beleaguered data processing departments simply give users permission to get their own systems. In other cases users are getting their systems without asking whether anyone else thinks they should or not. In such cases there are no comprehensive plans. Implementation of completely new systems in these decentralized operations will expand the number of applications the organization must support, while displacement of services provided by central data processing can duplicate systems already provided by the organization. In either case, costs rise.

Perhaps most importantly, without a coherent plan for conversion to decentralized operations it is likely that decentralized users will develop systems that clash with their current tasks and their interactions with other departments. As they begin to learn the deeper secrets of successful computing, especially the immutable importance of attention to precision and detail computing requires, they will find they must constantly adjust their systems and their operations to bring everything into harmony. If left alone long enough, things might "sort themselves out" through natural processes. But this can take a long time and exact a considerable toll in frustration and resources.

It is possible to make a coherent plan for decentralization, but this too will be expensive because the technical details and the interests of the different parties involved make the task complicated, and there are considerable costs for implementing even well developed plans. The dilemma in the case of organizational control and planning for decentralization is that there are high costs from either no control or careful control. Careful control requires a commitment to explore the options, work out the compromises, and make the considerable up-front investment in planning necessary to execute a coherent change. There must be some incentive for top managers, data processing professionals and users to seek the creation of a plan. Often the incentives are not present, or at least not present in equal measure for all, and gradual evolution toward decentralization might be the easier course. Unfortunately, this approach is often more costly in the end, as changes must be made to "reintegrate" computing operations with top management desires and to restore coherence in computing uses and activities.

Decentralization of computing is likely to increase the costs of computing for most organizations as new users of computing expand their uses of technology (possibly without careful thought about net benefits to the organization), and as the process of decentralization demands management attention and/or causes disruptions in normal affairs. The former problem arises from some behavioral factors that influence how and why people acquire new technologies. The latter is a consequence of any major organizational change. Whether the investment that decentralization of computing requires of the organization is warranted depends on the benefits to be derived from the move to decentralize.

4.2.3.2 Decentralization benefits: possibility and reality. There are several commonly hoped-for benefits from "stand-alone" decentralization (i.e., the establishment of small, independent computer activities in user departments). It usually provides users with easier access to the technology, which can result in greater use. It can increase user involvement in system design and modification, resulting in systems of greater utility to the users. It can increase user sophistication in the use of the technology, thereby enabling users to make more efficient and effective use of the technology. Finally, it allows users the opportunity to decide for themselves how computing best can be of service to them.

These benefits of decentralization can accrue to users, and thereby to the organization overall, provided that the other factors that enable such benefits are present. Easier access and increased use will only be beneficial as long as the uses themselves are beneficial. Users must know how to distinguish wasteful from productive uses. User involvement in design will produce systems of greater utility only if users are sufficiently knowledgeable about computing to design-in the most productive features while leaving out fancy but costly "wish list" features. Users almost certainly will learn more about computing, but this knowledge must be comprehensive enough to engender a sophisticated understanding of computing and its role in the organization. Where users will acquire these knowledge skills is unclear. There already exists a shortage of high quality data processing personnel, so hiring complete staffs of specialists for user departments will be prohibitively expensive. Vendor-provided training might be technically valuable, but is unlikely to teach the more subtle skills of evaluating and judging the worth of systems needed to make users discriminating in their assessments. Users must become sufficiently savvy in their understanding of computing to exploit the benefits of improved access to and involvement with computing that decentralization affords, while making the correct decisions about how to use their control wisely in the organization's interests.

These concerns apply to stand-alone decentralization, but there are additional concerns that arise with "networked" decentralization. There are a number of predicted advantages to be had by combining decentralization strategies with telecommunications and networking technologies. Users will have the ability to "share" machines, thereby avoiding the loss of large available capacity from centralized arrangements. They will be able to tap into network-wide data bases, reducing data redundancy. They will be able to interactively use their own and other machine or network resources and data, and integrate their work with others in the organization. Networking requires interdependency of equipment, reducing the tendency of decentralized units to adopt equipment that is incompatible with other units. Finally, networking can improve relations among units, facilitate organization-wide controls and computing management, and reduce problems of maintaining top management control common to decentralized, stand-alone systems.

These benefits from networked decentralization are technically feasible, but they are less likely to occur than are the benefits from stand-alone decentralization noted above. They depend on technological capabilities that are not yet proven, and on organizational behaviors that are not common. The ability to actually share computing resources among networked machines is limited at this time. The major experimental networks (e.g., ARPANET and the CSNET) do not allow actual linking of machine resources, but merely allow users to communicate with other network users or to move to the machine of their choice to conduct their work. Computing power is not shared among machines, but among users and host organizations, using a heavily subsidized recharge system that radically distorts the cost picture perceived by both hosts and users. There are more serious limitations with the emerging network technologies, especially local area networks designed to allow machine-to-machine communications at high data rates. The goal of designing such networks is to enhance communications among users, and allow users to use different resources available through the network. Such networks could, in theory, provide a means for having both centralized and decentralized computing simultaneously. Shared functions (e.g., large processors, data bases, special machines or peripherals) could be provided from one location but available to all through the network. Local users with their own processor and storage capabilities would also be able to use the shared resources through the net. The technical problems with this approach might be solved in time, but as yet networks are not available in the same sense that mainframes or terminals are [100]. There are also unresolved management concerns, such as who will be in control of the network and who will be allowed to connect to it. At this time networking is highly experimental, with the attendant risks of experimentation.

The implementation of organization-wide data bases on networks also presents problems of control over data that could be even more difficult than in large centralized computing installations. Information provides users with power in proportion to the desirability of that information to others, and few organizational units are comfortable giving other units or higher management open and easy access to their data. Centralized data processing forces departments to relinquish and centralize data. Once users have their own systems, there will be no centralized authority to enforce data sharing through direct sanctions on computing use. Formal rules governing access to data are weak mechanisms of enforcement, since there are are many ways for users to make the actual accessing of the data costly to those trying to get it. Users with their own computing capability can be difficult to hold in compliance with organization-wide rules. Data sharing will not necessarily be increased by networked decentralization.

Increased interaction among users might not be facilitated by networked systems. Communication does take place through experimental networks such as ARPANET and CSNET, but it is dangerous to infer too much from these experiments because they involve unusually sophisticated users (technically sophisticated academics, researchers, and professionals) with the needs and skills to communicate with others on their highly subsidized nets. For most organizations the integration of work through networked computing will be a long time evolving, and will entail substantial costs as users learn what the networks facilitate and what they do not.

Compatibility of equipment will not be ensured by networking unless highly centralized control is maintained to ensure that compatibility is an ironclad requirement for procurements. Networked arrangements contain the same forces that create pressure for incompatibility in other organizational contexts. In extreme cases, decentralized organizational computing centers have been known to adopt the strategy of "maximum feasible incompatibility" in computing equipment and operating systems procurement to prevent other centers from absorbing them. The organizational decision to decentralize computing might be reversed, so it is sometimes in the interest of decentralized user departments to make such a reversal difficult and costly for organizational management to implement.

Networking decentralized computing establishments will not necessarily facilitate managerial control because possession of computing capability is nine-tenths of the law in control of the technology. Decentralized units that are permitted to acquire their own capability will seek to build up their capability to meet their own needs, possibly weakening the ties to the network and reducing managerial control options. Without serious top management restrictions on capability and activity at the unit level, and real control reserved at some central node under direct managerial control, there is only the budgetary process and broad-brush, top-down policy to enforce management expectations on user behavior. Such weak enforcements often prove to be more costly and less effective than the more direct control of resources that a central computer center provides. Networking by itself is not likely to strengthen management control of decentralized computing activities.

4.3 The Interaction of Political and Economic Considerations

Both political and economic considerations are important in the centralization vs. decentralization debate. The importance of each depends on the situation at hand. When there is considerable organizational upheaval underway, political considerations can overshadow economic factors entirely. This can happen when departments are competing with one another for resources to expand, where top management is seeking to reestablish its control authority, or where a new managerial strategy is being implemented (e.g., a move from highly central corporate control to divisional control). In other cases, the economic issues can enable undercurrents of change to come forward as serious options, or even force changes in order to take advantage of new opportunities. The high costs of computer processors required many organizations to move departmental data processing activities to centralized units, and the declining costs of computer processors enables a movement of such activities back to departments. Other economic factors, such as the rising costs of software development and maintenance, the costs of networking, and the problems of supply and demand in the DP labor market can have equally important effects.

Neither the political factors or the economic factors can be considered universally dominant. Both influence decisions in important ways. However, the fact that many organizations have chosen and stayed with less economical arrangements suggests that political factors often are paramount. This observation requires some qualification: the question of what is "economical" might entail more than simple costs and benefits, and include other considerations, such as a desire to pursue a particular organizational strategy even though it is expensive because it is thought to yield long-run benefits. Nevertheless, the politics of organization and resources should be considered a fundamentally important factor in the centralization vs. decentralization debate. Economic issues, while important, are frequently merely weapons in debates about centralization/decentralization policy that are in fact based on political factors. This does not mean that the economic issues are unimportant. Rather, it means that the larger set of factors behind the call for either course of action must be considered. The following section addresses the basic management options for centralization/decentralization policy with these factors in mind.

5. MANAGEMENT OPTIONS IN CENTRALIZATION vs. DECENTRALIZATION

At base, the issue of whether to centralize or decentralize computing revolves around balancing needs and desires of those at the center against those in outlying units. The debate usually turns on questions of costs and benefits, but what is a cost and what is a benefit often depends on where one sits in the organization and what one's goals are. Many different organizational interests are at stake. The fundamental question, when one looks carefully at the issue, is who will have control over computing procurement, use, and management?

If the issue were solely economic there might not be the fervor one often finds. The traditional literature suggests that centralization generally is less costly to the organization than decentralization. As the assessment of economic dynamics above implies, this is likely to remain the case despite falling entry costs for computing. But other factors beyond simple economy are involved, and the economics involved are often complicated. The challenge facing managers is to find an arrangement for computing that provides users with the means to meet their computing needs, as well as experiment with and learn about the technology, without writing a blank check for computing or creating problems for management control and organizational operations. This section will summarize the major management options for dealing with this challenge, and suggest a strategy for finding the appropriate option given organizational conditions.

5.1 A No-Option Option

Before reviewing the major options, it is critical to point out that managers do not have the option of letting the issue resolve itself in a convenient and appropriate manner. There are two reasons why this option is foreclosed. One is the continuing presence of organizational factors that keep the debate alive, regardless of the strategy followed. The question is not whether the issue must be addressed, but when and how often. The other is the disappearance of automatic managerial control over computing growth resulting from the declining significance of computer procurement decisions. When mainframe costs were high the scale of computing purchases forced computer procurement decisions to higher management, and issues regarding how the technology would be used and controlled could be addressed. As computer prices have dropped, so too have the procurement thresholds to be crossed in acquiring a computer. Unless managers want to issue categorical directives governing procurement and use of computers, which in itself raises difficulties (e.g., is a sophisticated programmable calculator a computer?), users that want small computers will probably find ways to acquire them. And even categorical directives about procurement of computer systems can be disobeyed, subverted, or simply ignored.[18] The new realities of the centralization/decentralization debate require managers to face and deal with a much more complex set of decisions than in the past.

5.2 The Centralization Continuum

Figure 1 presents the major options managers have in arranging for the three major aspects of centralization/decentralization: control, location, and function. Each is presented in terms of a continuum between extreme centralization and decentralization strategies. The category in between, intermediate arrangements, does not capture all possible points between the extremes, but does illustrate how one might arrange a compromise. Generally, extreme centralization strategies consolidate control in one place in the organization, usually toward the top. They centralize facilities into a single site that provides all basic computing service and resources, though possibly providing remote user access through on-line services. They consolidate functions under the central control agency and within the central facility. Extreme decentralization strategies, conversely, devolve control over computing to user departments, permit user departments to establish their own facilities, and allow user departments to carry out the functions of computing activity according to their own arrangements. Note that even extreme decentralization does not preclude some organization-wide controls, facilties or functions. There still might be a need for such centralized arrangements to take care of organization-wide tasks such as personnel management. The key factor in extreme decentralization is that user departments are free to acquire their own computing capabilities and build their own computing operations.

The intermediate arrangements illustrated in Figure 1 have certain aspects of control, location and function reserved to the center, while other aspects of these dimensions are devolved to user departments. In the examples shown, the primary discriminator between centralized vs. decentralized arrangements is corporate needs vs. user department needs. For example, control over how much and what kinds of equipment users purchase is reserved to the center, but given central approval, users can procure their own systems. Major computing resources might be consolidated for efficiency, but smaller-scale computing installations can be established in user departments. Special functional resources such as systems programming or network management could be preserved corporate control, while applications programming and local data management could be the province of the department. A central control agency would exercise oversight and review to ensure that departmental decisions conformed to organizational objectives.

FIGURE 1. MAJOR MANAGEMENT OPTIONS IN CENTRALIZED VS. DECENTRALIZED COMPUTING

	CONTROL	LOCATION	FUNCTION
Extensive Centralization	Consolidation in one place all decisions regarding computing procurement, system development and maintenance, priority setting for systems work and resource usage, accounting for resource use, and responsibility for evaluation of computing's contribution to the organization and quality of service. Users make inputs to these decisions through advisory mechanisms, such as an advisory board, or by direct contacts between the central control unit and departmental management and users.	Establishment of one (or very few) consolidated facilities for provision of computing resources and services, including processing, storage, major peripherals, and physical environments (e.g., terminal rooms, tape storage). Allow users access to these resources and services through remote terminals and RJE equipment, installed and maintained by the central facility, and maintain contacts with users for service requests by establishing appropriate mechanisms (e.g., assigning "account managers" to different user groups to deal with user needs and problems.	Consolidation of all major computing functions (e.g., hardware operations, systems and applications programming, telecommunicatins, quality control, documentation, maintenance, and systems management) into one or very few centers, co-located with the centralized facility. Require departments to conform to central protocols for use of these functional resources. Training of users done by the centralized resource. Allow users to manage only those computer-related functions directly related to their departmental activities (e.g., data entry). Allow user participation in system design. Have users evaluate the service provided by the centralized functions.
Intermediate Arrangements	Retention of central management control, either through an appointed executive or a committee (which might include user representatives), over all major computing procurements (e.g., choice of vendors, large purchases, compatibility standards, and networking characteristics), all organization-wide systems deceisions, setting of organization-wide computing priorities, accounting for systems investments and use, and monitoring of system quality. Allow users to make department-level decisions for departmental computing equipment procurement, departmental systems planning, quality control, and systems management, but under strict guidelines provided by the central control group. The central control group would either directly enforce organizational guidelines, or would suggest to higher management when and what enforcement actions are necessary.	Consolidation of major computing resources (e.g., large and expensive equipment, data bases, network facilities) into one or very few centers, and make these available to users through remote access equipment. Allow users to create their own facilties for smaller-scale, department-related computing activity. Maintain oversight of the scale of user operations to ensure against extensive duplication and waste. Establish, where appropriate, networking among central and user facilities to allow transfer of data and files, and sharing of resources.	Consolidation of major functions (i.e., highly specialized or expensive functions) such as sytems programming, telecommunications management, data base management, network management, or quality control. These might be consolidated in a "pool" arrangement provided by a major facility, or as a staff function of upper management. Allow users to acquire their own functional capabilities for department-related needs such as applications programming and local data base management. Users manage and maintain their local facilities.
Extensive Decentralization	Devolution to user departments most or all decision making authority over procurements, system development and maintenance, priority setting, system use accounting, and quality control. Enforcement of organizational expectations about productivity resulting from user-based computing activities would be through normal merit review and monitoring of departmental computing activities.	Devolving to users the right to establish their own computing facilities where they choose to do so. Require users to utilize centralized facilities only when necessary to meet organization-wide needs when these needs cannot be met through use of networking.	Devolution to users the authority to establish their own functional resource centers, and permit total user control over fitting the activities of those resource-providers into departmental operations. Users provide for their own facility management, quality control, and training, though perhaps through contractual deals with other departments.

Each alternative has advantages and drawbacks. Extreme centralization keeps computing activity and growth under control of the center. It can allow efficiencies from economies of scale, and provide substantial overhead justification for procurement of expensive but specialized capabilities (e.g., powerful equipment or personnel with exotic skills). It enables direct and generally effective control over adherence to organizational standards in system design and quality, and makes computing activity easy to keep track of by top management. On the other hand, extreme centralization can result in the creation of an insensitive bureaucracy that fails to provide users with what they need and want, and that is difficult for users to interact with. In some cases, centralized operations grow lazy and fail to encourage the exploitation of new opportunities computing might offer. Moreover, centralized service providers must account for their expenses, which tend to be significant and organizationally obvious. If computing is provided as an overhead item, top management often will wonder whether good use is being made of this expensive function. If computing services are charged back by billing users for service, users often feel they pay too much for the services they receive. This is exacerbated if there are frictions between the central computing service and user departments. When backlogs for development of new systems grow long, which they do when maintenance demands of existing systems grow large, users begin to wonder whether their best interests are served by the centralized facilities. The lure of low entry costs for getting their own computing capability provides a strong incentive for departments to lobby for decentralization, backed up by the "evidence" of poor service and high costs from the centralized facility.

Extreme decentralization provides much greater flexibility for users in exploiting computing technology and adapting it to user needs. It gives users the opportunity to learn about computing in much greater detail, which can eventually make them more effective consumers of this technology. Properly handled, it can build up the computing talent of the overall organization by creating a "grass roots" computing culture throughout the organization. It can enhance the willingness of departments to accept changes that might be beneficial to the organization. Most importantly, it can result in productivity improvements when sensible applications of the technology take place at the departmental level that could not or would not be provided by centralized service. The drawbacks of extreme decentralization are that overall organizational costs of computing are likely to rise. This is acceptable if productivity improvements rise commensurately, but this will not happen unless the departmental uses of computing are well planned, well executed and well maintained. New users have yet to learn the lessons their more experienced counterparts have learned, and the price for this learning can be dear. The investment the organization makes in bringing new users up to competence (which is often buried in other costs) can easily offset the productivity gains from decentralized computing. Departmental personnel who become competent in computing soon discover the marketability of their new talents, and either demand wage increases or leave for better opportunities. If they stay, they can begin to see themselves as more appropriately aligned with the career of computing than with their functional responsibilities, causing personnel problems. Perhaps most important for top management, extreme decentralization can make it very difficult to keep computing activities in conformance with organizational goals. If control over computing truly devolves to users, users can easily make organizationally suboptimal decisions. Once their facilities and computing operations are in place, the costs of change to conform to new organizational guidelines can be prohibitive. Giving away control is often easier than getting it back.

Intermediate arrangements appear to be promising as compromise solutions, and they can fulfill this role.[19] It can be very effective to retain centralized control, facilities, and functions in cases where this is necessary or desirable, while allowing limited decentralization where the payoffs are likely to be high. Thus top management might reserve to the center those activities and functions upon which the organization as a whole directly depends, while allowing users to take advantage of the technology within guidelines ranging from strict to relaxed, depending on circumstances. This strategy will probably characterize most computer-using organizations in the future, since circumstances in most organizations make it sensible to compromise. But intermediate arrangements have important drawbacks. The question of which compromise arrangement to pursue is difficult to answer, and in its own way embodies the problems of the overall centralization/decentralization debate. It is sometimes impossible to differentiate between computing activities that are organization-wide and those that are department-specific, because some serve both purposes. Yet the question remains: should control be left to the center or to the outlying units?

Intermediate strategies also require extensive attention from both top management and departmental management. Planning and executing an intermediate arrangement requires creation of protocols to govern who is responsible for what and in which cases. Since intermediate arrangements do require some control to be devolved to user departments, central management must find a way of letting that control go while encouraging departmental management to conform to the goals of the overall organization. Once arrangements are in place, they must be maintained and enforced. The creation of a compromise does not eradicate the root causes of centralization/decentralization disputes. It merely finds a way of acknowledging the different interests in the debate and providing them with at least some of what they want so they can get on with the organization's business. The same changes that affect the traditional centralization/decentralization debate will affect any compromise.[20]

5.3 Mixed Strategies

The discussion thus far has focused on the advantages and disadvantages of three points along the centralization/decentralization continuum. It is not necessary, however, to maintain the same level of centralization across all three dimensions of control, location, and function. For example, some organizations have long maintained centralized control and facilities, while decentralizing to users the opportunity to acquire their own applications programmers or other functional capabilities. These mixed strategies (as opposed to intermediate arrangements) can work well. But a very important observation must be made about them. Theoretically, one could choose any In practice, the choices are more limited. The most effective way to explain the realistic options is to note that mixes can only be made by choosing cells across and down to the right of Figure 1. Thus it would be possible to have highly centralized control, somewhat decentralized facilities, and cell from each column in Figure 1 when determining computing arrangements.

widely centralized functions. It is not feasible to choose mixes moving upward to the right. The reason for this is the critical influence of control arrangements over all other arrangements, and the influence of location over function. As noted earlier, control cannot be equally shared among everybody involved in computing if organization management is to maintain the ability to direct the uses of computing to organizational goals. The moment one faction loses in a dispute, it is clear that the winning faction has control over that issue. Control over computing really means somebody in control.

This does not imply that a federation of independent users cannot form a consortium and pool their resources to establish a centralized computing facility with centralized functions. This can and does happen. For example, the federation of local governments in Denmark created a nation-wide service organization called Kommunedata which provides computing service to nearly every local government in the country [114]. But such examples do not apply to this discussion for several reasons. In the first place, the practical effect of the federation's action is to place somebody (i.e., the central facility's leadership) in control. A board of directors representing the federation might provide some policy direction and hire and fire the director of the service, but they cannot practically control the function of the service from the top down. Second, most arrangements of this kind (including Kommunedata's) soon begin to feel the tugs of centrifugal force as members of the federation want to pull out and develop their own capabilities. If the independent units do retain control, this is an option they can pursue. If they cannot pull out, they have relinquished control.

This raises the issue of the relationship between location and control, and the influence of location over function. As noted earlier, in the control of computers possession is nine-tenths of the law. Those who control centralized facilities have great power to direct the actions of users of the facilities through their policies and practices. Their power derives from the simple but effective sanction of witholding or restricting service to user departments that fail to comply with facility management. Centralized facilities will usually be responsive to highly centralized, top management controls, again in keeping with the rule of "across and down to the right" in Figure 1. But they need not be responsive to a consortium of users, especially if no one user or minority group of users can effectively split off to establish their own facility. Of course, in the end the centralized facility must meet the minimum demands of their clients or the complaints of the clients will bring top management to bear on the issue.

Location, or facilities in the case of computing, influences function in the same way that control influences facilities. Functions that are dependent on computing are tied to the facilities they utilize, and must conform to the demands of the facilities. They also share affinity with the facilities, since they are computing-related and the facilities have the computers. Centralized facilities with decentralization of functional resources such as programmers to user departments can create in these programmers split loyalties. They serve their departments, and may even depend on departmental evaluations for their employment and advancement, but they are part of the culture of computing. They need access to the computing resources the facility has, and they share common bonds of knowledge and career with facility staff. Yet even with split loyalties it is possible to have centralized facilities and decentralized functions as long as the responsibilities of the decentralized specialists to their operating departments are clear. When facilities are decentralized but functional personnel are centralized they find themselves facing the problem of employees in "matrix organizations": their administrative home is in the central department or pool, but their actual performance takes place in the decentralized departments or facilities. The people who evaluate them for advancement within the pool do not have much contact with the work they actually do. Eventually, there is a tendency for these functional specialists to want to move their positions to the facilities and departments they serve. Thus, decentralized location encourages decentralized functions.

The realistic options for arranging control, location, and function in computing therefore tend to flow downward from control arrangements. This limits the options suggested by Figure 1, but is advantageous in that it reduces the number of alternatives management must consider. As long as control is seen as the crucial dimension of the centralization/decentralization debate, and the arrangements for location and function correspond to the behavioral realities that arise from control decisions, sensible arrangements are possible.

5.4 Choosing an Option

Given these options, the final question to be faced is which option is appropriate for a given organization. There is not sufficient room here to provide examples of all the cases in which various configurations might be appropriate, but there are some guidelines for the process of deciding that are useful.

First, control must be recognized as the most important issue in making centralization/decentralization decisions. Because control issues are so critical in all aspects of organizational life, most organizations have developed sophisticated ways of dealing with them. The prevailing norms of the organization can provide good guidance for dealing with control over computing. If the organization is highly centralized in most aspects of its operations, a highly centralized control arrangement for computing is probably sensible. Similarly, if the organization follows highly decentralized control policies, such as establishment of operating units as profit centers, decentralization of control might be necessary and desirable. Most organizations have a range of control arrangements, depending on what is being controlled. Decisions about control over computing should parallel those organizational arrangements governing activities that are similar to the activities of computing. Thus, if most of the organization's use of computing consists of financial control applications, and financial control activities are centralized, centralized computing control should be appropriate. On the other hand, if computing tends to be a general purpose resource used for many different kinds of applications at the department level, and departmental managers have considerable autonomy in how they run their operations, some decentralization of control to these managers might be appropriate. The key here is to ensure that the control arrangements for computing are not wildly out of keeping with other organizational practices. Computing practices should not be thought of as tools by which the basic behaviors of organizations can be changed.

Second, the issue of control must ultimately be decided by managers at the center of the organization. They retain responsibility for overall organizational operation and performance, and cannot avoid being judged for their decisions. Whether there is a deliberate policy regarding control of computing or an unconscious evolution of policy, the results remain the policy of central management. Central managers should remember that devolution of control over computing toward decentralization can be profitable in some circumstances, but it can also be a source of many problems if not done appropriately and in a manner that ensures benefits for the organization. Recentralization of control can be difficult or even impossible, and will usually be expensive. Decisions about decentralization of control over computing should be made with great care.[21]

Third, managers should be cognizant of the ramifications of computing location decisions. If location decisions are being made before questions of control have been answered, these decisions should be delayed until the issue of control is settled. The decision to decentralize computing location often has the practical effect of decentralizing control. Centralized control and decentralized location is possible and perhaps desirable, but it can only occur when the arrangements are thoughtfully worked out and implemented.

Fourth, location decisions should only be made after careful assessment of the actual uses the organization makes of computing. If the uses made depend on availability of computing capabilities that are only available from large and expensive processors or other costly resources, it might be infeasible to decentralize because important uses would suffer degradation in performance by moving to the smaller machines that usually accompany decentralization. Many organizations have discovered too late that the small machines departments have purchased are incapable of handling the applications. Not only must current applications be reviewed, but future growth should be considered. Many smaller computer systems have limited expansion potential. Failure to carefully review the present and future applications of computing can result in naive expectations about what computing resources will be required. Central facilities will probably be best for applications that require large-scale computing resources or that have organization-wide implications. Decentralized facilities will be appropriate only for applications that make limited demands on computing equipment and that serve only user department needs. Certain computer-based tasks such as word processing are so directly tied to users that equipment to do them must be decentralized in many cases.

Fifth, centralization/decentralization of location questions should be based on the realities of current technologies, not on expectations about new technological possibilities. Emerging data communication technologies expand the options for deploying computer equipment. They permit networking that can allow users access to more than one of the organization's computers. Users with their own smaller computers will be able to conduct local processing and upload and down-load data and files from central computers. Departments will be able to conduct their own computing at the departmental level, while handling upward reporting of data to management through the network. While these technologies might eventually provide such capabilities, they will not alter the constraints in location decisions for some time to come in most organizations. This technology is still in its infancy and it is still experimental. Only the most technically advanced organizations are endeavoring to install sophisticatd network systems. If past trends in diffusion of new computing developments hold true, the majority of organizations will not be able to adopt this technology for at least five years. Most importantly, networking does not alleviate the problems of control raised by decentralization of location, and in some cases it can create new problems. At the least, networking is an integrating technology, and as such brings with it the difficulties associated with integrated systems noted in section 4.2.3.2. New technologies do not provide a simple fix for the problem of centralized vs. decentralized facilities.

Sixth, current arrangements should be evaluated carefully before deciding to change to a new set of arrangements. Often the problems with present arrangements stimulate demands for major change, but these problems might be attenuated by minor changes in current arrangements. For example, if users are complaining about long system development backlogs and other problems from centralized computing service, a careful analysis might reveal that increasing the resources of the computing center could meet these user needs at lower cost than establishing decentralized facilties and functions. Conversely, if decentralized arrangements are causing trouble for integrating applications and meeting organizational guidelines for compatibilty of equipment, more strict procurement protocols and centralized approval for procurements might bring practice in conformance without requiring recentralization of facilities. The problems of the current situation are often cited in requests for major changes in centralization/decentralization arrangements, but improving the current situation is an option easily overlooked.

Seventh, it should be recognized that there is a drive toward decentralization of computing among users, and this drive is likely to grow stronger as entry costs for computing decrease. Users prefer decentralization because they gain control of both the resources and the capabilities of computing. Decentralization allows users to set their own priorities for computing use and for new systems development, and gives them new claims on organizational resources. Also, many users want to obtain computers for their entertainment value. Computers are interesting and enjoyable to work with, which is an important factor in the success of computing in organizations. The development of appropriate computing arrangements requires a careful assessment of the role that each of these factors plays in the proposal to decentralize computing. Factors such as possible improvements in effectiveness and better user department uses of computing are likely to be cited, while a desire to gain new resources, increased budgetary leverage, or the entertanment value of computing will probably be left out. All of these factors can play a role in proposals to decentralize computing, and it is sometimes difficult to determine what is really at issue.

6. CONCLUSION

The debate over centralized vs. decentralized computing has been around for a long time, and will be around for a long time to come. Changes in the technology will not resolve the debate because the most important factors in the debate are grounded in constant reassessment of where control in organization activities ought to reside. Changes in technology merely alter the options available and the economies surrounding each option. Nevertheless, the debate must be resolved at least for the short run. Computing must be provided according to some arrangement, preferably one that services the subunits of the organization and the organization as a whole. There is no universal "best" solution, so each organization must find its own. The quest for this solution is not easy, but with proper attention to the endemic organizational issues surrounding the debate, the economics of various arrangements, and the prevailing norms and goals of the organization, it is possible to construct an arrangement that will serve until new technological or organizational developments force a reconsideration.

NOTES

1. The author's address is Department of Information and Computer Science, University of California, Irvine, CA 92717. This research was supported in part by grants from the National Science Foundation. The author acknowledges helpful contributions from Kenneth Kraemer, Kathleen King, Herb Schwartz, Nicholas Vitalari, and two anonymous reviewers.

2. This article deals specifically with computer application to administrative data processing. It does not address the special cases of process control applications such as computer aided design and manufacturing that typically do not require intra-organizational data sharing. However, many of the issues discussed here apply also to such applications.

3. This review is based on more comprehensive papers by the author [57,58]. It should be noted that the issue of centralization and computing can be viewed as a policy issue (i.e. what centralization/decentralization policies should be followed in computing arrangements), or as a question of computing's impact on organizational structure (i.e. does computing use result in greater or lesser organizational centralization). This paper deals only with centralization as a policy issue. Centralization as an artifact of computing use is reviewed in [58] and [112].

4. This issue was usually discussed in terms of the finance and accounting departments of organizations, where the first computerization of administrative data processing usually took place.

5. This section relies on an extensive tradition of research in organizational behavior, most of which takes place outside field of computing use in organizations. In particular, it draws on the work precipitated by Cyert and Allison [2], Arrow [4], Burns and Stalker [18], Chadwick [21], Child [22], Cyert and March [26], Downs [35], Lawrence and Lorsch [75], Meyer [87], Moore [89], Niskansen [92], Perrow [102,103], Wildavsky [137] and Yin [141]. This list is by no means exhaustive. Of particular importance to this analysis is the observation, articulated well by [2,26,35,92,103], that the idea of genuine "organizational goals" can be illusory. The overall directions taken by organizations might appear to follow coherent policies aimed at consistent goals, but in fact they are often fabricated by internal organizational conflict, and are undergoing frequent change. In the field of computing use this important point is raised by Kling and his colleagues [65,67], and is found in [27,28, 58,60,61,61,64,66,69,70,71,72,82,86,106,116].

6. The importance of entertainment value in the success of computing as a technology has been overlooked in most of the research on computing adoption and use. Yet, the success of computer-based entertainment products and the use of games as major marketing tools by computer vendors suggests that this is an important factor. The author's own experience in consulting and research indicates that most people are curious about computers and desire to experiment with them and use them. Resistance to use of computing seems to persist only as long as there is uncertainty about the impact of computer use on one's job and status within the organization.

7. This history is an admittedly hypothetical synthesis based on the commentaries of many who experienced and wrote about the evolution of computing use in organizations over the past two decades (as found in the references). Many organizations never had the experiences reported here. The history is for illustration of the ways in which various factors interact in the centralization vs. decentralization debate.

8. Excellent accounts of the influence that computer-generated reports can have are found in [28,64,79].

9. Budgetary leverage refers to the role computer use can play in justifying increases in departmental budgets. In this respect, computing is like many other organizational activities (particularly those with bureaucratic characteristics) that justify and enhance the organizational positions of the units that carry them out [27,64,72,82,137].

10. Policies of this kind are discussed in [28,62,70].

11. This account is of necessity constrained by a lack of detailed, empirical assessment of computing's economic impact. Useful references to this subject include [63,105,110].

12. There has been considerable discussion in the literature about alleviating this problem [9,25,41,76]. One of the most common proposals is to develop means of improving the productivity of individuals who develop software [9,10,25,33,50,76,78,91,105,116,143]. Whether such methods and tools will make up the difference is unclear. If they do not, it is likely that equilibrium will be achieved by attenuation of the number of systems developed.

13. This estimate is derived by taking the stimate of DOD expenditures on software of $5 billion per year [9,41], and multiplying this by the estimates of maintenance as a percentage of overall costs for military software, thought to be between 50-80% [9,77].

14. The fact that little rigorous research has been done does not mean that tangible benefits do not accrue from advanced applications. Edelman [36] presents data suggesting that direct economic benefits from cost savings and avoidance do occur from such applications in some circumstances.

15. This assumption is based on a common assumption in theories of welfare economics: that households are the best determiners of their own welfare. There are obvious exceptions in which intervention is required from outside agents (e.g. experts), but as a general rule this assumption seems reasonable.

16. Systematic research on the adoption and use of computers in the home is now being conducted by Nicholas Vitalari and Alladi Venkatesh at U.C. Irvine.

17. The author thanks Suzi Iacono for assitance in compiling this information.

18. The author is familiar with one military organization that circumvented federal regulations centralizing procurement of computers by buying microprocessor-based diagnostic equipment not covered by the regulations, removing the microprocessors from the equipment, and throwing the rest away. Most administrative rules have loopholes.

19. Intermediate arrangements such as those suggested here have been the subject of many recent articles on organizing the use of computing and information technology in organizations. See in particular [1,14,55,81,87,113,124,139].

20. A popular approach for incorporating the ideas of outlying units into direction provided from the center is to utilize committees. This approach, which has been enshrined in the perspective literature on the management of computing, is being recommended as a means of dealing with the new era of centralization/decentralization issues [95]. Research into the effectiveness of user committees suggests that they are not very effective at solving major political problems in the management of computing [62,70,73]. It seems the basic problems of control remain. The growing literature on the subject of citizen participation provides a useful analogy to the problems faced by incorporating users in political decision processes. For example, Arnstein's "ladder of participation" suggests that there are eight "rungs" representing levels of actual power conferred on participants: citizen control; delegated power, partnership; placation; consultation; informing; therapy; and manipulation. Only the top three confer genuine power on committee members, and these of course require that actual power be relinguished from the center. The middle three rungs provide for some opportunity to assess the desires and frustrations of committee members, but action on these remains the perogative of the existing elite. The bottom two rungs can actually result in deterioration of performance because the committee can serve as a shield behind which inadequately performing central actors can hide while maintaining the appearance of sensitivity to users. Perhaps the most useful role committees can serve is to help improve the sensitivity of both DP specialists and users to one anothers' needs and problems, and facilitate what political scientists call "mobilization of bias" among participants around genuine problems that can be solved by collective action.

21. It is frequently suggested in prescriptive literature on the management of computing and data processing that top management should be actively involved in decisionmaking about DP. Recent resarch suggests that intensive involvement of top management in such decisions is associated with higher levels of computing problems, although why this is the case is not clear from the data [62,73]. More often, what DP managers need is not the involvement of top management, but their <u>support</u> for decisions the DP manager makes. A lack of top management input to decision making still allows for appropriate decisions to be made in many cases, but a lack of top management support for the DP managements' decisions can easily cripple implementation of those decisions.

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FIGURE 1. MAJOR MANAGEMENT OPTIONS IN CENTRALIZED VS. DECENTRALIZED COMPUTING

	CONTROL	LOCATION	FUNCTION
Extensive Centralization	Consolidation in one place all decisions regarding computing procurement, system development and maintenance, priority setting for systems work and resource usage, accounting for resource use, and responsibility for evaluation of computing's contribution to the organization and quality of service. Users make inputs to these decisions through advisory mechanisms, such as an advisory board, or by direct contacts between the central control unit and departmental management and users.	Establishment of one (or very few) consolidated facilities for provision of computing resources and services, including processing, storage, major peripherals, and physical environments (e.g., terminal rooms, tape storage). Allow users access to these resources and services through remote terminals and RJE equipment, installed and maintained by the central facility, and maintain contacts with users for service requests by establishing appropriate mechanisms (e.g., assigning "account managers" to different user groups to deal with user needs and problems.	Consolidation of all major computing functions (e.g., hardware operations, systems and applications programming, telecommunicatins, quality control, documentation, maintenance, and systems management) into one or very few centers, co-located with the centralized facility. Require departments to conform to central protocols for use of these functional resources. Training of users done by the centralized resource. Allow users to manage only those computer-related functions directly related to their departmental activities (e.g., data entry). Allow user participation in system design. Have users evaluate the service provided by the centralized functions.
Intermediate Arrangements	Retention of central management control, either through an appointed executive or a committee (which might include user representatives), over all major computing procurements (e.g., choice of vendors, large purchases, compatibility standards, and networking characteristics), all organization-wide systems decisions, setting of organization-wide computing priorities, accounting for systems investments and use, and monitoring of system quality. Allow users to make department-level decisions for departmental computing equipment procurement, departmental systems planning, quality control, and systems management, but under strict guidelines provided by the central control group. The central control group would either directly enforce organizational guidelines, or would suggest to higher management when and what enforcement actions are necessary.	Consolidation of major computing resources (e.g., large and expensive equipment, data bases, network facilities) into one or very few centers, and make these available to users through remote access equipment. Allow users to create their own facilities for smaller-scale, department-related computing activity. Maintain oversight of the scale of user operations to ensure against extensive duplication and waste. Establish, where appropriate, networking among central and user facilities to allow transfer of data and files, and sharing of resources.	Consolidation of major functions (i.e., highly specialized or expensive functions) such as sytems programming, telecommunications management, data base management, network management, or quality control. These might be consolidated in a "pool" arrangement provided by a major facility, or as a staff function of upper management. Allow users to acquire their own functional capabilities for department-related needs such as applications programming and local data base management. Users manage and maintain their local facilities.
Extensive Decentralization	Devolution to user departments most or all decision making authority over procurements, system development and maintenance, priority setting, system use accounting, and quality control. Enforcement of organizational expectations about productivity resulting from user-based computing activities would be through normal merit review and monitoring of departmental computing activities.	Devolving to users the right to establish their own computing facilities where they choose to do so. Require users to utilize centralized facilities only when necessary to meet organization-wide needs when these needs cannot be met through use of networking.	Devolution to users the authority to establish their own functional resource centers, and permit total user control over fitting the activities of those resource-providers into departmental operations. Users provide for their own facility management, quality control, and training, though perhaps through contractual deals with other departments.