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CENTRALIZATION vs DECENTRALIZATION OF INFORMATION SYSTEMS: A CRITICAL SURVEY OF CURRENT LITERATURE

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The issue of centralization of information systems has been widely and emotionally debated for almost two decades now. It is no surprise, therefore, that the published literature on the subject is quite extensive. Furthermore, the centralization-decentralization problem is complex and important enough, so that a significant portion of the entire EDP management literature has bearing on it.

The literature related to the centralization problem is not only voluminous: much of what has been written is repetitious, and sometimes, outdated. As a result, there is no point in summarizing extensively the entire literature on the subject.

The approach taken by the CISR Research group includes an annotated bibliography which lists a major portion of the literature on the subject (CISR Working Paper No.). This paper, by contrast, concentrates on a few key publications relating to one aspect of the problem: the centralization/decentralization decision. It summarizes the major points in each, and offers some critical remarks.

Three groups of articles are reviewed:

- General issue discussions: a comprehensive table of advantages and disadvantages of various configurations is presented, along with a discussion of a few important contributions, viewed from a decision making perspective.

- Discussions of distributed systems: being a relatively new and seemingly attractive alternative to both centralization and decentralization, distributed systems merit a closer look.

- Organizational behavior issues: although least discussed in the literature, organizational development issues may well be among the most important considerations in the configuration decision.

Issue Discussions

Articles on the advantages and disadvantages of centralization and/or decentralization abound in the literature. Since different authors have different assumptions and approach the problem somewhat differently, the arguments are not strictly comparable. For this reason, there is little point in reviewing the articles in depth individually. Instead, a table summarizing most of the pro and con arguments advanced in the literature is presented in Exhibit 2-1.

The remaining part of this section is devoted to illustrating current thinking on the centralization-decentralization decision. To this end, three articles are reviewed in depth: one, by Norton, is a survey of the arguments and research on the subject. The other two, by Withington and Glaser, are attempts to provide some guidelines for decison making.

Norton - three categories of MIS activity

David P. Norton, in a Harvard Business School paper intended to become a chapter in a forthcoming book , observes that "the term "centralization" is meaningless when applied as a generality to information systems. Instead, the concept of centralization must be approached in terms of the specific functions which make up the operations and management of an organization's information system" Accordingly, Norton groups information systems related activities into three categories:

- System operations, including physical hardware as well as the operations and maintenance personnel directly associated with the computer.

- Systems development, including the analysis, design and programming of new computerized applications, as well as the maintenance of existing applications.

- Systems management, encompassing the administrative aspects of planning, developing, operating and controlling the organization's information system.

Norton proceeds to list the major arguments for and against centralization in each of the above categories. Some of his major points will be reviewed below:

On system operations, Norton presents the law attributable to Herbert Grosch, ("that the effectiveness of a computer system - in terms of speed, throughput, etc. - was proportional to the square of the costs"), and some empirical studies (by Solomon and Knight) which prove it. Both studies, it should be noted, refer solely to the IBM/360 family of computers and to CPU costs. Operating systems and peripheral operations are not considered. Other arguments on operations include the applications which need information crossing division boundaries (for centralization), the complexity of operating systems, risk of failure, high communication costs, and competition for priority of service (all against centralization).

Norton subdivides systems development into its analysis, design and programming phases. He reports that there exists a "fair consensus" that the analysis phase should be performed locally (decentralized). With regard to design and programming, personnel and technical specialization considerations are advanced as arguments favoring centralization. Empirical results summarized by Norton show that in practice "it is the location of the hardware which determines the location of both analysts and programmers."

No clear consensus can be found with regard to system management functions, according to Norton. Most authors writing normatively agree that some of these functions should be centralized, but there is

little agreement on the exact definition of these functions. It seems that most authors would recommend centralization of the long range EDP plan, of standards, equipment selection and the like. Descriptive literature on systems management (Garrity, A.M.A., Dean) is conflicting and not very instructive.

Norton's paper, then, is an excellent summary of the types of arguments and studies currently available in the literature on the centralization-decentralization problem. His categorization of information processing functions , systems operation, system development and systems management is particularly valuable. Norton's most important insight in this respect is the identification of systems management as a separate group of activities (inspired, in part, by Glaser, whose paper is reviewed below). As Norton observes, "the administrative planning and control tasks undoubtedly have more influence on the effectiveness and efficiency of an information system than any other variable".[1]

On the other hand, Norton displays also the most important weakness of the current literature on the subject: his list of "situational - variables" notwithstanding, the article does not give much help to the decision maker charged with choosing the "correct" configuration for his organization. Such a decision maker would need to know which situational variables are relevant and how they affect his decision, and how he should compare different configurations. Such a decision making approach is not offered in the current literature.

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[1] Norton, David P.: "Information System Centralization: The Issues", Harvard Business School Paper 9-172-286, 1972, p. .

Withington - some alternate configurations

Frederic G. Withington's writings in E.D.P. management[2,3] exemplify another approach to the centralization problem. Briefly, Withington identifies forces leading to EDP centralization and the problems with centralization, but concentrates on presenting examples of combined centralization-decentralization solutions to the problem, and attempts to generalize from those examples.

According to Withington, there are basic universal forces leading an organization to centralize its EDP effort. These forces are:

- cost of duplicate system development
- desirability of standard equipment
- desire for uniform management reporting
- shortage of expert personnel
- economy of scale in computers

The problems with EDP centralization include:

- wish to delegate authority and responsibility
- fear of poor service from central facility
- fear of expensive overstructure

Withington proceeds to discuss "common alternatives" to pure centralization or decentralization:

- Operations centralized and system development left to divisions - This is an alternative most often adopted in large organizations producing highly technical products, such as aerospace manufacturers, with large amounts of scientific and engineering processing.

- System development centralized and operations dispersed - This is an alternative usually found in large business organizations with geographically dispersed divisions performing identical functions, none of them of such a nature that very large computers are required.

- Central control of equipment acquisitions and central development of applications common to an entire functional area - This compromise is generally found in large, geographically dispersed companies "whose divisions and subsidiaries have products representing a compromise between diversity and commonality".

- One larger centralized computer plus smaller satellite computers and remote job entry terminals, and centralized development augmented by small development groups for unique local needs - a compromise somewhat simpler than the one above, more appropriate, according to Withington, in smaller and less diversified companies.

- Centralization of policies for equipment acquisition and personnel training, some centralized standards, and common systems for management reporting. Withington sees this alternative as most appropriate to multi-national corporations, where multilingual and multicultural factors exist, and different equipment is superior in different countries.

Another factor, the parent organization's authority structure, is identified by Withington as important in determining the chosen information system configuration. Those organizations "accustomed to central control move earliest and most strongly to centralized data processing; those most devoted to decentralization move slowly, carefully, and with maximum compromise". Note that this factor is added to product diversity and geographical dispersion, identified above.

Withington, then, goes beyond the standard approach (that of listing advantages and disadvantages) in two ways. First, he presents some actual examples of successful configurations using some combination (or compromise) of centralization and decentralization of specific functions. Second, and even more important, Withington identifies specific characteristics of the organization which determine the chosen information system configuration. Note, however, that Withington's approach is basically descriptive. As such, it cannot be inclusive or rigorous: what, exactly, are the possible combinations a company could use? What are all the characteristics affecting the choice between them? The answers to these questions, critical for good decision making, are not given by Withington.

Glaser - pragmatic common sense

George Glaser[4], a principal in McKinsey & Co., is exceptional in that he directs his paper to the decision maker, and gives practical rules for the decision making process, in addition to the standard arguments for centralization and decentralization.

Glaser gives three general rules for approaching the centralization-decentralization decision:

- the organizational approach to data processing should be consistent with the overall operational approach of the company in which it functions.

- no change should be introduced unless the projected benefits of transition are both large and concrete.

- no organizational structure or policy will work unless accepted by the majority of people affected by it as logical, satisfactory and workable.

He then identifies seven primary criteria for deciding between centralized, decentralized or combined policy:

- minimum total cost
- user satisfaction
- effective utilization of personnel
- the ability to attract and retain personnel
- rational selection of development projects
- the opportunity to share common systems
- adaptability to changes in the technical and economic environment

Additional factors influencing the decision are:

- volume of information to be consolidated
- response time required by operating managers
- availability of reliable and inexpensive data communications
- the company's"state of D.P. art" (if introducing D.P. for the first time - would prefer to centralize. As the group expands and matures, it may be more desirable to decentralize).
- decentralization or centralization of current operations
- heterogeneity of applications among divisions
- the degree of uniformity of coding systems, managerial practices, and operating policies within the corporation.

Glaser admits that "there are an infinite number of possible organizational structures that might be offered to deal with the issues discussed above". However, according to Glaser, most existing structures are variations on four major alternatives:

- centralized development and operations
- independent development and centralized operations
- independent development and operations under central coordination
- independent development and operations

Although none of the alternatives above includes system development by both central and divisional staffs, Glaser does offer guidelines for when to allocate tasks to a centralized staff as opposed to allocating them to the divisions. According to him, the centralized staff should be responsible for the following:

- the work of the corporate office
- company wide functions
- divisional work that doesn't require rapid turnaround time and can be done more economically centrally
- work for small divisions that cannot justify facilities or staff of their own
- interdivisional and interplant applications that are part of an integrated system where, for technical reasons, a single computer must process all data within the system.

In contrast, decentralized staffs should be responsible for:

- applications that depend on rapid turnaround
- all work for which there is no compelling reason to centralize.

There can be no question that George Glaser's article is a major contribution to the information systems centralization-decentralization literature. It is a practical and intelligent article, which, although, brief, covers most of the major facets of the problem. One major

criticism can, however, be advanced against Glaser's effort: his approach is somewhat informal, and as such, it is less than rigorous. Glaser gives "general rules for approaching the decision", "criteria for deciding", "additional factors influencing the decision", and "guidelines for allocating tasks to a centralized staff". What, exactly, is the difference between the above groups? How does one apply them to make an optimal decision?

Even for unstructured, strategic planning decisions, there can (and should) be an orderly, rigorous approach for generating and choosing alternatives. No author, including Glaser, offers such an orderly method for the centralization-decentralization decision. (We dwell on this point - for it is a primary goal of our existing research project in this field.)

		centralized systems	decentralized systems	distributed systems
GENERAL AND ORGANIZATIONAL CONSIDERATIONS	Advantages	-easier consolidation of company-wide operating results -ease of control & coordination by corp. management -enhances corporate consolidation -can lead to integration of other administrative functions (e.g., purchasing) -easier to implement and maintain standards -shared development costs -small user access to large CPU -a greater variety of services & programs can be offered -user relieved of mgt. & operation of computer facility -easier to direct overall use of computing	-profit and loss responsibility -familiarity with local problems -rapid response to local needs (also less formal) -special programs & services can be tailored to divis. needs -easier communication between DP & user (more involvement) -"hands-on" experience for users possible -more flexibility in coping with crises and changes in plan -better service - under user control -"flexibility in aligning EDP with organiz. philosophy"	-feeling of exclusive use by user organization -when use standard equip. .develop. or shared basis .transfer of personnel between divisions easier .reduce no. of separate equipment studies .can move computers between departments
	Disadvantages	-management problems associated with large staffs -prone to cause barriers to acceptance -more likely to cause political problems -higher risk of failure	-strict controls & standards requir. to prevent duplic-ation of softw. develop. - not as professional EDP mgt. -separate equip. acquis. studies & interchangeability	-additional controls & standards for: .ensuring communications between sites .safeguard access to distribut. data base -people in DP required to serve two masters

Exhibit -1 Pro and con arguments from the literature

		centralized systems	decentralized systems	distributed systems
ORGANIZATIONAL CONSIDERATIONS	Disadvantages (cont.)	-more rigid: any change may have serious ramifications -requires more top mgt. involv. -more vulnerable to corporate overhead reduction -management problems associated with centralized organ.: .standardization effort .expense allocation & pricing .assigning performance responsibility .agreement on priorities .scheduling problems		-problems of network management: .income allocation .expense allocation .assigning performance responsbility .agreement on priorities
COST FACTORS	Advantages	-economies of scale in main-frames -economies of scale in mass storage devices -reduced record storage duplication -reduced site preparation & protection costs -fewer operators required -fuller utilization of processing capability	-lower communication costs (more critical in future when cost data transfer -modest start-up costs -low incremental expansion cost -higher share of raw computing power available to user -avoids certain user-computer communication costs -better cost/performance - faster reaction to new tech. advances	

Exhibit -1 (2)

		centralized systems	decentralized systems	distributed systems
COST	disadvantages	-may require costly controls -danger of expensive overhead	-some idle resources -possible duplication of software costs	-high costs for extensive conversion
PERSONNEL CONSIDERATIONS	advantages	-general shortage of competent D.P. personnel -better availability in metropolitan centers -more efficient use of personnel talents (specialization) -larger & more expert pool of consultants -broader career opportunities = more attractive position -higher standards due to more competitive salary levels -personnel turnover less critical -cross fertilization -rotation of personnel more natural	-greater interest & motivation at local level -identification with the mission of the sub-org. -less risk of personnel turnover -more opportunities to communicate with (and transfer into) line management -less skilled personnel required	
	disad.	-chances for Peter-Principle effects		

Exhibit -1 (3)

		centralized systems	decentralized systems	distributed systems
TECHNICAL CONSIDERATIONS - PROGRAMMING	advantages	-more sophisticated software - better service to programmers and users .sys. software can provide help .greater selection of prog. lang., debug-aids, etc. -can handle large programs - no need to break up problem -easier to implement data base technology -economies of integrated requirements	-smaller programs - need handle only one local situation -easy to satisfy "hands-on" requir. for testing purposes -easier to add new applicat./ services (esp.O-L) -forces modular programming - easier to debug & maintain -progressive approach to installing systems (projects break up naturally) -less specialized support	
	disadvantages	-multiprogramming limits programmers -virtual storage conflicts with modular programming -mutual interdependence between jobs complicate both develop. & operations -more experts - can handle more complex applications	-forces modular progr.: difficult to implement -problems with current minis (additional): .little addressable space .non compatibility (even within brands)	

Exhibit -1 (4)

		centralized systems	decentralized systems	distributed systems
TECHNICAL CONSIDERATIONS OPERATIONS	advantages	-reduced mean & variance of turn around time = improved service -agreater variety of services & programs can be offered -less disruption when user moves (if both sites use same facil.)	-more fault tolerant design -easier to add new services -less specialized support necessary -newer hardware technology on average	-higher reliability (fail soft) -better data communicat. performance (fewer errors) -flexibility as to location of site -chance for better security
	disadv.	-system software complex & resource consuming	-user may want to step up to more elegant system -more frequent breakdowns	

Exhibit -1 (5)

Literature on Distributed Systems

Distributed systems hold a special place among currently feasible computer configurations, simply because they present a new and attractive alternative to totally centralized or decentralized systems. Unfortunately, the term "distributed processing" means different things to different people. The term is mentioned, however, mostly in relation to hardware configuration. For the purpose of this paper, a "distributed system" is a system of interconnected computers (CPU's) with their own mass storate, each at a different organizational location. Such a system may offer some of the advantages of both centralization and decentralization, and thus is an important alternative for consideration.

Canning - distributed processing

Probably the most eloquent advocate of distributed processing is Richard G. Canning, editor and publisher of the excellent E.D.P. Analyzer[5,6]. Canning's 1973-4 vision of a distributed system included "mini-hosts" - mini-computers with a relatively simple operating system that operated in a mono-programming mode - interconnected via an ARPA-type network, with each data base accessible from any other mode, all under a "system wide discipline". (Recent developments, including the IBM 3790 make parts of this vision, e.g. mono-programming, too simplistic.)

Canning points out the fact that the economies of scale for centralization is weaker than is apparent: multiprogramming and virtual storage waste CPU cycles and complicate programming and operations; centralization calls for large application and centralized data base systems, again hampering efficiency; and large computers lag in implementing new advances in technology, both in hardware and in operating systems.

Canning sees important advantages to distributed systems: first, they support - even enforce - modularity in system design and operations, and are thus more able to deal with the growing complexity and dispersion

of users. In addition, Canning foresees the continuation of the trend to remote input and interaction. Distributed systems hold down data communications costs, improve reliability, and give operating people a sense of ownership and participation, and thus will better support the above trends.

Current technological trends will diminish current economies of scale in mainframes and possibly also mass storage devices. At the same time, no breakthrough in communications cost is expected, making their relative costs much higher in total D.P. costs.

While mini-computers (and hence distributed systems) are currently limited in their software and programming support, a distributed system does offer many of the advantages of both centralization (e.g. consolidation of operating results, etc.) and decentralization (e.g. user control).

In conclusion, Canning admits that the future of distributed systems depends somewhat on IBM's policies, as well as other manufacturers, but proposes considering distributed systems in a company's long range plans.

The arguments for distributed processing are, clearly, very logical. There can be little doubt that distributed systems, in one form or another, will continue to be implemented in the future in certain situations. As some new computer architectures which employ several peripheral processors (e.g. IBM's 370/125 and CDC's Cyber 70 series) make clear, the argument of economies of scale in computer production breaks down at a certain size. There is no reason why, for example, a group of mini-computers in one room would be <u>always</u> superior to a group of geographically distributed interconnected mini-computers.

This, however, does not mean that distributed systems will be superior in all situations. Canning's implicit assumption that one configuration will "win out" is disputed by both logic and experience. And this, it seems, is the article's major weakness: similar to the "advantages - disadvantages approach" described above, Canning's article argues for one configuration rather than providing guidelines for choosing one of several feasible configurations.

Rosenthal - distributed data base

While Canning concentrates (though not exclusively) on the advantages of distributing processing, D.B. Rosenthal discusses distributing data bases[7]. Rosenthal advocates taking "portions or subsets of the corporate data base, and putting them out in the remote locations, where the data is created, is used, and where decisions are made based upon it, and at the same time isolating exception and summary data, which the headquarters location needs for its data base, and send this up at appropriate time intervals".

"The results of such ... a distributed data base system can be:

1. Better control and direct use of data by those who are most concerned with it.
2. Substantially lower communication costs
3. Lower overall installation costs
4. Faster implementation of a company wide information system".

Rosenthal advocates, basically, what Canning calls a "hierarchical-distributed system" - a three or more level hierarchy of processors, roughly parallel to organizational levels. Such a system is also envisioned by Richard Sprague, one of the pioneers of the computer field.

According to Rosenthal, the total costs of such a system may well be lower than that of a centralized system: while hardware may be somewhat more expensive, both software development and communications are expected to decrease in costs.

Most importantly, as Rosenthal stresses, such a system is not a thing of the future. Built around the relatively recent availability of small, full-capability, fully supported communication-oriented computers, with superior price-performance levels, such a system is clearly feasible today. "It is is simply a network of small systems, each doing the wide variety of jobs that each remote location must accomplish, in what is basically an autonomous environment, but with the added capability of relating to the next level in the overall system, through the exchange of that information each needs to successfully fulfill its job in the corporate structure."

Like Canning, Rosenthal does not discuss those conditions under which a "distributed data base system" should be preferred (except for specifying a multi-locational company). Furthermore, he does not specify the characteristics of the applications which should be distributed.

To conclude this section on distributed processing, it is important to mention the fact that several mini-computer manufacturers, Datapoint, Digital Equipment, and Hewlet-Packard in particular, have started advocating (and supporting) the concepts of distributed processing outlined above. This enhances the feasibility of implementing such a configuration, and makes the understanding of the choice process even more critical.

Organizational behavior issues related to the problem

Of all the issues involved in the centralization-decentralization question, the ones concerned with organizational behavior are the least well understood. The literature described above, and indeed most of the literature on the problem, rarely mentions these problems, let alone solve them.

What is involved is an understanding of the impacts of different configurations of computerized information systems on the organization, and, no less important, the impact of changing from one configuration to another.

Demb - An approach to understanding organizational issues - and some data

A very important step towards understanding these organizational impact is the one by Ada B. Demb, presented in her Ph.D. dissertation and a subsequent CISR Report[9]. Demb's major contribution lies in her application of organizational development frameworks to the centralization problem. In addition, Demb presents a field study of a centralization effort in a ten-campus public college system. The major theoretical points and concrete findings presented in her report are summarized below.

Demb distinguishes in her framework between two important aspects of an EDP development effort:

- the process of planned change (and its impacts)
- the internal organization dynamics

In assessing the impacts of planned change, Demb uses a model for consultation developed by Kolb and Frohman[10]. Based on this model, Demb identifies four particularly critical aspects of the problem:

- the collaborative nature of the change effort
- the need to establish priorities

- the need for feedback
- the need for an evaluative mechanism

In understanding organizational dynamics impacts, Demb identifies five issues:

- actor characteristics
- interaction characteristics
- interdependence - often a root of conflict over change in organizations
- the widely-differing expectations of the actors involved
- the need to assign clear responsibilities among actors

Demb used her theoretical framework as a way of analyzing the public college system centralization effort. On the change process, Demb concludes that:

> "At the study site, dissatisfaction with the information system centralization process revolved primarily around difficulties which arose as a result of the management of change process itself, rather than the specific characteristics of the centralized system. Using the model of change ..., the bases for some of the difficulties can be identified and traced in specific stages."

Even more important for our purposes, Demb presents several major findings relating to impact on internal organization dynamics:

- Those "actors" who would be most affected when application systems were standardized (as often occurs with centralization) perceived a major threat to their authority, and reacted accordingly.

- The process of developing shared applications, where central staff depended on users to define their needs, tended to create a great deal of tension for those involved.

- Those users who were most dependent on the computer staff and were concerned about system failure, reacted extremely negatively to the centralization effort.

- Political factors - the reactions of influential individuals, general organization climate and local norms and politics, play a critical role in the centralization process.

As mentioned above, Demb's effort is particularly important because the subject of organizational impacts of centralization has been so little explored. Demb's framework would be very useful in attempting to assess further organizational impacts, when studying other centralization or decentralization processes. The only criticism that can be raised in connection with her work, is that the one case study she presents is not a sufficiently large sample to enable drawing generalized conclusions. In particular, it is impossible to single out contingencies relating to the whole organization. Some of her conclusions (especially the ones concerning the process of change) should be regarded as tentative, until we have been able to compare studies of several, different organizations.

Demb's framework attempts to predict some (specific) effects of a centralization effort, assuming that a decision to centralize has been made. Yet, her results are obviously very relevant for the centralization decision: for example, if there is an unavoidable, significant, negative impact of centralization, it should be taken into account in the decision to centralize. No less important, the costs and effects of change are an integral part of the centralization-decentralization choice.

Summary

This paper presents an overview of the current literature on the centralization-decentralization issue. Three groups of articles are surveyed:

- general issue discussions, where most of the literature available presents advantages and disadvantages of centralization-decentralization
- literature on distributed systems - the newest type of configuration. This literature, again, is mostly stated in terms of advantages and disadvantages
- an article covering the organizational behavior aspects of centralization

As was observed in this paper, the current literature does not offer an orderly model for making the configuration decision, and is, thus, only partially helpful to management for decision making.

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