CENTRALIZATION VERSUS DECENTRALIZATION OF INFORMATION SYSTEMS: A CRITICAL SURVEY AND AN ANNOTATED BIBLIOGRAPHY

by

Jacob Akoka

November 1977

CISR #36

Sloan WP #1003-78

updated annotated bibliography

by Christine Bullen

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Introduction

The literature dealing with the issues related to distributed management information systems is rapidly expanding. This literature may be classified in two categories:

- the management-oriented literature which is concerned with the issue of centralization versus decentralization of information systems and the management of distributed processing;
- the technically-oriented literature which deals with issues such as optimizing distributed networks and currency control in computer networks.

This survey deals only with the first aspect of distributed systems.

In the first part of this paper, a critical study of the state of the art in distributed management information systems is provided. In the second part, an annotated bibliography related to the issue of centralization versus decentralization of information systems is presented. This bibliography updates the one published by the Center for Information Systems Research (CISR) (1976) (1).

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(1) Rockart, J.F. and Leventer, J.S., "Centralization versus Decentralization of Information Systems: An Annotated Bibliography, CISR Report 22, April 1976

The author is indebted to Professor P.P.S. Chen for his help.

I. CENTRALIZATION VERSUS DECENTRALIZATION OF INFORMATION SYSTEMS: A CRITICAL SURVEY

The issue of centralization versus decentralization of computer resources is not a new one; it has been widely discussed and hotly debated for at least two decades now. The interest in this issue was originally motivated by the feeling that the computer, a costly expense in terms of investment and operating budget, should be used to the fullest possible potential. Interest also grew because it was felt that within a corporation, a large measure of political power rested with whomever controlled the data processing facility. Lately advances in network technology and the advent of efficient low cost mini and micro computers has initiated the era of distributed data processing and in effect thrown new fuel into the centralization/decentralization fire.

Of the voluminous literature published on this subject, we first concentrate on key articles relating to one aspect of the problem: the centralization/decentralization decision. Management, faced with decisions regarding proper long range directions toward optimal configurations of hardware, software, and personnel finds little by way of guidelines to follow. There seems then to be a real need for a rigorous decision model to provide management with an approach to solving this dilemma.

Ernest Dale (2) states: "the proper balance between centralization and decentralization often is decided by necessity, intuition, and luck because of the immense variety of possible human behavior and vast multiplicity of minute, undiscoverable causes and effects that cannot be encompassed in

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(2) Dale, E. "Centralization versus Decentralization," Advanced Management, June 1955.

any principal or standard of evaluation." In addition, current solutions seem highly dependent on the characteristics, philosophies, and objectives of the particular organization for which the decision is to be made. According to George Glaser (3), "the organizational approach to data processing should be consistent with the overall organizational approach of the company in which it functions." The problem is not only of major importance but of substantial complexity also.

Having surveyed many articles available in the literature it is clear that, with few exceptions, most articles fit one of the following categories:

- a general discussion of advantages and disadvantages of various configurations as viewed from a decision-making perspective;
- the establishment of decision criteria from specific corporate functions;
- a proposed decision model by which management can make qualitative decisions about organizational directions based on specific data processing applications;
- a discussion of distributed systems as being a new and attractive approach to the centralization/decentralization decision.

The first group of articles is very general and focusses on discussions of advantages and disadvantages of various configurations. From a functional point of view, most applications could be accomplished by either

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(3) Glaser, G., "The Centralization versus Decentralization Issue: Arguments, Alternatives and Guidelines," Database, Fall/Winter 1970

centralized or decentralized approaches. However, as G.A. Champine (4) states, "each of the two approaches has advantages and disadvantages. In general the advantages of a centralized approach are the disadvantages of a distributed approach and vice versa." For example, some of the advantages and disadvantages he lists are:

"Centralized advantages/distributed disadvantages"

- Operations economy
- Hardware economy of scale
- Unified control
- Easy interfile communications
- Easy update/retrieval
- Compatibility

"Distributed advantages/centralized disadvantages"

- Communication failsoft capability
- Central site failsoft capability
- Lower communication data rate and costs
- Configuration flexibility
- High speed performance (fast response and high transaction rate)
- Modular upgrade

Dozens of authors have written similar articles citing specific advantages and disadvantages. Some of these articles are described below:

Reynolds (5), argues that three economic considerations have to be taken into account: personnel to operate the hardware, data processing

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(4) Champine, G.A., "Six Appraoches to Distributed Databases," Datamation, May 1977

(5) Reynolds, C.H., "Issues in Centralization," Datamation, March 1977

applications programming efforts and the computing. All three considerations can lead to some economic saving when implemented in a centralized way. Reynolds uses his own organization, Hughes Aircraft Corporation, as an illustration of his argument.

Kieder (6) argues that two considerations are critical in arriving at the most effective type of organization for a particular corporation - i.e. corporate structure itself (irrespective of data processing tasks performed) and size and location of the corporation.

Wofsey's (7) article is mainly a discussion of the respective advantages and disadvantages of both the centralized and decentralized approaches to systems design.

Finally, Burnet and Nolan (8) argue that the technology has now matured to the stage where the cost of using a mini for certain data processing jobs compares favorably with using a portion of the capacity of a large machine.

In some articles this approach takes a more general form. Louis Fried (9) exemplifies this in his article when he states, "As part of the continuing discussion that is almost as old as the computer industry, there have been as many reasons advanced for decentralization as for centralization. However, in contrast to the arguments for centralization, which center around efficiency, the arguments for decentralization center around effectiveness." It is my contention that this first group of articles is too general and diverse from which to draw any meaningful generalizations

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(6) Kieder, S.P., "Once again Centralize or Decentralize," Infosystems, December 1976

(7) Wofsey, M.M., "Centralization versus Decentralization," Management of EDP Systems, 1973

(8) Burnet, G.J., and Nolan, R.L., "At Last Major Roles for Minicomputers," Harvard Business Review, May-June 1975

(9) Fried, L., "Centralization: To Be or Not To Be," Infosystems, January 1976

in terms of decisions regarding optimal solution. As Rockart et. al. (10) state, "The 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, their arguments are not strictly comparable."

The second group of articles approaches the discussion of centralization versus decentralization in terms of corporate functions. These articles are far more useful in that they propose specific ways of looking at the decision. Norton (11) reiterates this point by stating, "Generalization is meaningless when applied as a generality to information systems. Indeed, the concept of centralization must be approached in terms of specific functions which make up operations and management of an organization's information system." Accordingly. Norton groups information systems related activities into three categories: systems development, systems operations, and systems management. Each of these categories can be defined functionally as follows:

Systems Development: This includes system design, the development of detailed specifications and programs, implementation plans, and maintenance plans.

Systems Operations: This includes the editing and control of input and output, updating data files, processing, and the reporting of results.

Systems Management: This includes planning long range directions and projects, and maintaining control over the entire facility.

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(10) Rockart, J.F., and Leventer, J.S., "Centralization versus Decentralization of Information Systems: A Critical Survey of Current Literature," CISR Report 23, April 1976

(11) Norton, D.P., "Information Systems Centralization: The Issues," Harvard Business Review, 9-172-286, 1972

He then goes on to more rigorously define these activities and observes that the administrative planning and control tasks undoubtedly have more influence on the effectiveness and efficiency of an information system than other variables. Carl H. Reynolds (12) takes a similar approach to that of Norton's. He divides data processing facilities into three components: "the computing hardware," "personnel required to operate the hardware," and "data processing applications programming efforts." These categories less rigorously define the activities of a data processing facility and are therefore less useful.

This approach, by which the problem is divided into smaller pieces, leads to the third category which consists of only one article. Rockart et. al. (13) follow Norton's reasoning that activities performed by information systems are three distinct processes: systems operation, systems management, and systems development. Since each is an independent process, the decision to centralize or decentralize can be made independently for each one. The authors further segment the problem by looking at the decision in light of the applications being performed. Their proposal is then basically that decisions to centralize or decentralize can be made separately for each of Norton's processes (system development, system operations, and system management) and each group of closely related applications of being performed. Rockart's model does offer general guidelines for management to follow. It takes a step in the right direction in that the model proposes concrete procedures to follow. Although Rockart relies on mainly qualitative methods of evaluation, his division of decisions with regard to applications opens the door to quantitative evaluation methods. .

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(12) Reynolds, C.H., op. cit.

(13) Rockart, J.F., Leventer, J.S., and Bullen, C.V., "Centralization versus Decentralization of Information Systems: A Primary Model for Decision Making," CISR Report, 1976.

The last group of articles discusses distributed data processing as a new and promising trend in data processing configuration, which could eliminate the whole centralization/decentralization problem. John Lusa (14) states, "Some people are still arguing the comparative merits of centralizing or decentralizing infosystems activities. While the discussion goes on at a somewhat academic level, a relatively new phrase, if not necessarily representing a new concept, may keep the discussion at that level. Distributed processing has blossomed into major prominence as a technique for increasing the efficiency of a data processing operation to the benefit of the users." This new trend brought on by network technology and the advent of low-cost mini and micro computers has indeed created an appealing alternative for certain situations. Other authors such as John W. Luke (15), Richard G. Canning (16) and Tien Chi Chen (17), to name a few, take similar positions in favor of distributed data processing. Distributed processing

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(14) Lusa, J. M., "Distributed Computing Alive and Well", Infosystems, November 1976.

(15) Luke, J. W., "Unravelling the Confusion of Distributed DP", Infosystems, December 1976.

(16) Canning, R. G., "Is Your Future Distributed Systems?", EDP Analyzer, Vol. 11, No. 8, August 1973.

(17) Chen, C. T., "Distributed Intelligence for User Oriented Computing", AFIPS, Vol. 41, Fall 1972.

may well be the computing phenomenon of the 1980's, and it may well be the solution to some problems. However, mini computers and network technology will not solve all data processing problems. And the fundamental issue of which data and which computer processing should take place at the outboard end of the system (decentralized) and which inboard (centralized) still remains.

In conclusion I would like to offer Robert L. Patrick's (18) observation, "A mini is a good solution, sometimes. Decentralization -- or distributed processing, or distributed computing, or whatever -- is a good solution sometimes, but they are only good solutions to some problems. As in most things we do, the important work is in deciding whether the solutions we like fit the problems we have."

In surveying the literature, little was found in the way of hard conclusions. The centralization/decentralization decision process is still very subjective at best. But the factors involved in making centralization/decentralization decisions are now coming more clearly into focus.

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(18) Patrick, R.L., "Centralizing Hardware and Dispersing Responsibility", Datamation, May 1976.

II. CENTRALIZATION VERSUS DECENTRALIZATION OF INFORMATION SYSTEMS: AN ANNOTATED BIBLIOGRAPHY

Becker, Hal B. : "Preparing for Distributed Data Processing," DataComm User, January 1977, pp. 22-24

This article focuses on new network planning philosophy. It begins by defining the information network environment, stating the user's requirements, and then using a design sequence to identify specific hardware and software products. It's a particularly useful technique for distributed processing networks.

The author divides user requirements into three basic categories:

1. information processing, or manipulation of information in a way that produces the desired result;

2. network processing, or the movement of information between the various network nodes;

3. database or storage of information within the network in forms convenient to network users.

The author claims that the users requirements should be essentially independent of specific hardware, software and applications. These functional requirements are defined in terms of: topology, anticipated volume of information flow, existing information processing facilities, response time, availability, and security.

Using the requirement statement as input, the analysis and design sequence employs an iterative, interactive series of steps to derive a workable, optimum, economically justifiable network configuration.

Becker, Hal, B. : "Six Steps to Network Analysis and Design," DataComm User, March 1977, pp. 30-31

In this article, the author argues that in the structured approach to network implementation, the analysis and design sequence involves an iterative, interactive series of steps. It is iterative in that some or all of the steps may be repeated and it is interactive in

that it consists of a combination of automated algorithms and manually derived design and decision making processes. The sequence consists of six basic steps: the requirement statement, physical and logical design, performance prediction, installation/operation, performance validation and evolution.

Blair, James, F. : "Distributed Information Systems," Telecommunications, January 1974, pp. 39-40

Distributed information systems are defined here as a hierarchy of processors linked together, each of which may have human as well as database interfaces. A table defines the typical characteristics of six types of distributed information systems, however, the distinction among the types may blur in actual use. Two examples of DIS are presented: a communication network for the Texas Department of Public Safety, and one for Bancsystems Association of Cleveland, a credit authorization organization. By utilizing the concept of a hierarchy of processors for communications efficiency, many corporations and institutions are achieving cost effective systems. This will have an overwhelming impact upon the growing data communications industry.

Champine, G.A. : "Six Approaches to Distributed Data Base Systems," Datamation, May 1977

In this paper, it is argued that distributed databases offer a solution to the very real problems of geographically distributed organizations which need to preserve a unified information sharing and processing system. Computer industry trends, such as falling costs of processing and storage compared to more stable communication costs, are responsible for the increasing appeal of distributed database systems. The paper describes the two basic approaches to distributed databases which are to replicate the database at each node, which will work best where file sizes are small and communication costs high; or to partition the database, which works best when most transactions are to "local" large files. It is shown that when most transactions are not to local files and file size is large, centralization of some form may still be the economically justified answer.

Donaldson, Hamish, : "A Case for Distributed Processing," Data Exchange, July-August,1975, pp. 43-45

It is argued here that decentralized management needs decentralized computing, because: a) different divisions

have different needs, b) it requries a very strong manager to impose the same system on two different divisions, c) a changing business strategy requires flexibility. The author suggest one should develop common systems only where there is a very clear common need.

Regarding management, however, what seems to be required is, according to the author, a sort of dual management: business management from the user management and technical supervision from management services (i.e. DP). It is claimed that in small to medium sized companies central control is essential. In larger organizations more flexibility is possible and the advantages of centralized control must be weighed against potential dangers of over-bureaucratic interference. In summary, central control of systems development is usually desirable.

Edited : "Distributed Data Systems," EDP Analyzer, Vol. 14, June 1976, pp. 1-13

In this paper, it is claimed that one of the problems with distributed systems is deciding what functions should be distributed, where they should be distributed, how to control the operation of the hierarchy of functions, and how to insure database integrity. Some motivations for distributed systems are: 1) to enhance reliability, 2) to take advantage of falling processing costs, 3) to handle growing transaction volume, 4) to perform input validation on the spot. In this paper, it is argued that there are three main ways of partitioning systems:

1. Partitioning Of An Application System. Here the system designer must search for the natural clustering of activities.

2. Partitioning By Functional Area. Each department would probably have its own minicomputer system, and the several departmental systems might be tied together in some sort of network system.

3. Partitioning Of The Data Processing Function. Supporting remote data entry, handling data communications functions, or handling the database management.

Edited : "Distributed Systems and the End User," EDP Analyzer, Vol. 14, No. 10, October 1976

The article focuses on the numerous reasons which account for the growing interest in distributed systems. For

example, one reason is the reduction in overall operating costs that these systems promise. Another reason is that they give each organizational unit the resources to do its own data processing - to "control its own destiny" in the words of one executive. At the same time distributed systems may well bring radical change in the whole data processing environment, as we know it today. Almost all aspects of the data processing function - systems development, programming, data entry, and computer operations - may shift in the direction of the end user. This article includes the experiences of some organizations where such a shift has already started.

Edited : "Distributed Computing and the Mini-Computer," Canadian Data Systems, July 1974, pp. 38-39

This article claims that distributed computing means putting the computer power where the job is. The author asserts that by using the right small computer at the right place, there are increases of control and a reduction of communications costs. It is argued that only summary data needs to be communicated to other elements in an overall system. This article further lists areas around a plant where computer power should be distributed.

Edited : "Distributed Minis Score Over One Large System at Equitable," DataComm User, March 1975, pp. 51-52

In this paper, it is reported that the Equitable Life Insurance Society has implemented a series of distributed mini computer systems in aspects of its claims processing, and statistical analysis. It is argued that the mini's shorter implementation period, low implementation cost compared to large batch/on line computer systems, lower operating costs, and lower site preparation costs are factors which lead to the decision. Equitable uses the mini's for processing in real-time mode for the following applications: group claim payment system; calculations for group insurance compensations for agents; administration of medicare for the states of Idaho, New Mexico, Tennessee, and Wyoming; integrated group insurance system to maintain a unified data base with exhaustive premium and claim information for all policies; and a satellite programming office in Cresskill, New Jersey.

Edited : "Talking About Distributed Processing," Data Systems, February 1976, pp. 8-23

This article presents a number of different views on both the principle and practice of distributed processing. At the present time, distributed processing systems are evolving rather than being planned. It is argued that dispersed unconnected data processing systems are turned into distributed systems by the installation of communication links. Such systems have evolved through the need to retain vital data locally, and to improve the operation and control of remote systems. Problems connected with the concept are largely management oriented. The editor stresses the fact that the planning phase is vitally important and must be exhaustive and informed. Management must also solve the problem of security and lack of uniformity of accounting techniques.

Edited : "Talking About Networks," Data Systems, March 1977, pp. 7-9

This article indicates that there are now more than twelve major communication networks, private and commercial in the world. It is claimed that the implementation of a network raises many problems beyond those of its design. The article describes below some of these problems:

1. Standardization And Simple Interfaces To All Kinds Of Hardware And To Other Networks. The International Standards Organization has been largely concerned with this and was responsible for high level data link control. The issue has been complicated by IBM's introduction of systems network architecture.

2. Tariffs. Agreement must be reached between countries involved in networks which cross national boundaries. The difficulties of privacy and data security increase costs.

3. Demands Of Individual Government Authorities, Particularly In The Case Of Security And Privacy On International Networks. The author describes how some networks handle some of these problems.

Edited : "Distributed Processing Is In, Whatever It Is," Datamation, Vol. 22, December 1976, pp. 102-111

The article recognizes the fact that distributed processing appears to be flourishing in Europe. Most plans will be implemented in the next 3-4 years. Most are planning to put part of their databases and processing capability into intelligent terminal systems, microcomputers, and small business systems located at user departments or remote factory floors, distribution centers, and sales offices. Reasons tended to center on better services to end users, followed by cost implications.

It is claimed that the central site generally remains in ultimate control. Hardware selection and systems programming will be done by a central staff. Standardization is the reason for centralized control. Applications include order processing and inventory or stock control, production control and planning, and local management and financial applications. Most remote processors will have a portion of the database and will be in daily communication with the host processor.

Emery, James C. : "Managerial and Economic Issues in Distributed Computing," IFIP Proceedings, 1977, pp. 945-55.

"Discusses technological developments which have made it feasible to distribute processing functions, alternative computing configurations, and the centralization versus decentralization issue. The advantages and hazards of distributed systems are also examined." [from Quarterly Bibliography of Computers and Data Processing, Vol.7, no.4, January 1978.]

Fiedelman, Lawrence : "It's A Small World," Infosystems, Vol. 24, April 1977, pp. 50-54

In this article, the author argues that the distributed system using minicomputers is not the only means to meet the needs for multi-location data processing; in fact, it is in direct competition with large computer systems with on-line remote terminals. However, as the price of minicomputers continues to drop, extensive business software enhancements are introduced, data communications facilities become more economical, and the data processing manager develops more knowledge of how to handle this situation, we are seeing an ever growing trend toward distributed computing. The data processing manager will need to determine how such equipment can best be utilized and to identify system management implications.

Fried, Louis : "Centralization: To Be or Not To Be," Infosystems, January 1976

This article begins with the description of Citibank's data processing reorganization toward decentralization. It is claimed that change can be traumatic and the "average" corporation is advised to avoid it unless it is well justified. Arguments are presented citing advantages and disadvantages on both sides of the centralization/decentralization issue. The best structure in the end, seems to result from careful analysis of the total corporate requirements of data processing. After the many considerations are weighed, the best reorganization method should be tailored to fit an individual corporate situation.

Glaser, George : "Distributed Data Processing: Promises and Pitfalls," Proceedings of the IDC Conference on Distributed Data Processing, April 1977

George Glaser begins this article by refering to distributed data processing as "offering the joys of computerdom long promised by the industry." As with any reorganization plan the costs are likely to be high, but he cites this as similar to the costs of any technological advance. The author claims that the primary advantage of distributed processing is that it would improve the quality of service rendered by an enterprise, in that operating needs would be assessed more realistically and on a more timely basis. This is not to say reorganization toward distributed processing is not without problems. The author asserts that a battery of issues like spending authorities, development priorities, quality control, and standards will certainly challenge even the most experienced managers' skills.

Hannan, James and Fried, Louis : "Should You Decentralize," Computer Decisions, Vol. 9, February 1977, pp. 40-42

This article approaches the question of centralization versus decentralization from an advantages versus disadvantages perspective. Several systems incorporating the best of both are discussed, and specific criteria is outlined for making the decision.

Hunter, John J. : "Distributing a Database," Computer Decisions, Vol. 8, June 1976, pp. 36-40

The author reports that about a decade ago, there was a switch from remote processing to a new discipline of centralized computing. Some problems that came with centralization were enormous databases, data inavailability due to line failures, concern for data security, and overloading of the central processor. One answer to these concerns proposed by DP strategists is distributed processing. The user's files are placed at or near the

points where the transactions occur. This way the user's data are always available, and there is no worry about data communications failures.

Possible ways of distributing a database to meet the demands of the three most commonly used distributed processing networks - star, hierarchal and ring - are also also discussed.

Kelsch, August L. : "Dispersed and Distributed Data Processing," Journal of Systems Management, Vol. 29, No. 3, March 1978, pp. 32-37.

This article focusses on an organizational design which "marries" distributed and centralized data processing in an attempt to "maximize the availability of the computer as a business service tool." The author allocates operational responsibility to the end user of a distributed system and retains technical responsibilities in a centralized DP group.

Kieder, Stephen P. : "Once Again: Centralize or Decentralize", Infosystems, December 1976.

This article addresses the issue of centralization vs. decentralization of corporate data processing systems. The article cites two considerations as critical in arriving at the most effective type of organization for a particular corporation: 1) corporate structure itself irrespective of data processing tasks performed; and 2) size and location. The author finishes by citing several advantages are disadvantages for both systems.

La Voie, Paul : "Distributed Computing, Systematically", Computer Decisions, Vol. 9, March 1977, pp. 44-45.

It is argued that a system approach is mandatory in the field of distributed data entry and processing. The author claims that this new field promises important benefits both to the DP manager and to the user departments. The author argued that since distributed data entry and processing is a new technique, there are few standards and even fewer general systems design principles. This article contains some basic questions which should help DP management avoid some of these pitfalls.

Luke, John W. : "Unravelling the Confusion of Distributed Data Processing", Infosystems, December 1976.

The author claims that there is considerable divergence of views on the definition of distributed processing. As a consequence, it raises the question of whether distributed processing already with us or still a few years out in the future.

It is claimed that network services are already providing distributed processing. Integration of an on-site machine into a network enables utilization of all the systems resources while retaining control over the local installation. However, there are still software problems to be solved before the full potentialities of such integration can be realized.

It is argued that commercial networks have a formidable arsenal of advantages which are offered to their customers. Reliability is one of the most valuable features as well as hundreds of application packages. Thus the author claims networks offer the best of both centralized and decentralized worlds.

Lusa, John M. : "Distributed Computing: Alive and Well", Infosystems, November 1976.

This article suggest that distributed computing is blossoming into a technique of major importance for increasing the efficiency of data processing operations. "Distributed Data Processing might be described as the marriage of minis and telecommunications", and will mature into the electronic office of the future.

Patrick, Robert L. : "Decentralizing Hardware and Dispersing Responsibility", Datamation, May 1976.

This article states that at one time Grosch's law was more nearly correct. It may still be useful today when applied to the CPU cluster alone, but support costs, which are primarily personnel costs, rise more slowly than the costs of the computer configuration and therefore continue the argument that bigger is cheaper.

On the opposing side, the complexity of the entire system of hardware, software, and personnel, rises much more rapidly than computer power or costs. When that complexity rises to a point where it taxes our abilities to manage, it argues strongly against centralization inspite of any economies of scale.

As a conclusion the author claims: "A mini is a good solution, sometimes. Decentralization or distributed processing or distributed computing or whatever -- is a good solution sometimes, but they are only good solutions to some problems. As in most things we do, the important work is in deciding whether the solutions we like fit the problems we have."

Reynolds, Carl H. : "Issues in Centralization", Datamation, March 1977.

This article addresses Hughes Aircraft Company's decision to centralize their data processing functions. By doing so it was estimated that data processing costs could be cut by a factor of two.

The article centers on three economic considerations fundamental to making any centralization/decentralization decision.

First is the personnel to operate the hardware. Usually centralization offers some savings however as on-line processing comes into greater use, the operator expense will be less an issue. Also the ease with which multiple tasks can be performed by operators at smaller decentralized installations tends to lessen this expense.

The second issue to be considered is data processing applications programming efforts. Here one should expect savings from centralization only if there exists in a corporation common programming applications. In corporations with varied application of data processing facilities decentralization can be more economical.

The last issue to be considered is the computing hardware. Economy of scale does not seem to be as important an argument for centralizaton as it used to be due to the advent of inexpensive mini-computers: Tracking down system failures in smaller decentralized installations is easier and can in fact mean additional savings in data processing costs.

It appears that the centalization resulted in major cost savings for Hughes Aircraft Company in data processing functions. Some effectiveness might have been sacrificed but in terms of the individual data processing needs of the company, centralization was determined to be the better organizational structure.

Ritchie, Robert O. : "Intelligent Terminals and Distributed Processing", Computer Decisions, February 1975, pp. 36-42.

In this paper it is argued that intelligent terminals and distributed processing provide processing capabilities to remote locations, freeing the large central computer of menial processing tasks. Communication costs decrease, fewer I/O's are needed to the data base or mainframe, and the user has computational power unique to his requirements as well as a much more reliable system and independence from error-prone communications facilities. The author gives suggestions to help select hardware and software for such a system.

Rockart, John F. and Leventer, Joav S. and Bullen, Christine V. : "Centralization versus Decentralization of Information Systems: A Preliminary Model for Decision-Making", CISR Report, Sloan School of Management, MIT, Cambridge, Massachusetts (forthcoming).

Of the many organizational decisions facing management today one of the most difficult must certainly be whether to centralize or decentralize their data processing structure. In this area where guidelines are general at best, Rockart proposes a model which if used properly assesses each pertinent factor involved in a corporation and logically determines which functions within the data processing facility should be done locally and which functions should best be accomplished centrally. Thus the model is based on Norton's observation that the activities performed by information systems are in fact three distinct processes: systems development, systems operation, and systems management. Since each of these is an independent process the decision to centralize or decentralize can be made independently for each process. Further segmentation with respect to logical application groups can be made for both systems development and systems operations, however systems management is viewed as being a decision made for the corporation as a whole.

Rockart's decision model though entirely qualitative offers precise guidelines for management to follow. It is the most advanced model in this area.

Severino, Elizabeth F. : "Databases and Distributed Processing", Computer Decisions, Vol. 9, March 1977, pp. 40-42.

It is argued here that the concepts of distributed processing are maturing. This growth should play a role in the decision to install a distributed processing system. There are two kinds of processing power, horizontal and hierarchical. In horizontal distribution, all devices co-operate at the same logical level to perform a set of tasks. Rule and control are democratic. The processes exchange jobs or transactions so that the total workload is distributed. In a hierarchical scheme of distribution, the devices are interconnected to form a functional hierarchy. The sharing of tasks and other functional relationships are structured and all devices are controlled by a primary network computer. There are also hybri forms of networks that use both approaches and even networks that are dynamically reconfigurable.

Statland, Norman and Winski, Donald : "Distributed Information Systems: Their Effect on Your Company," Price Waterhouse Review, Vol. 23, No. 1, 1978, pp. 54-63.

This article examines the organizational and management implications of the distributed processing environment. The authors point out that too often the general manager has viewed the MIS department as an overhead cost which he/she wants to minimize, rather than seeing it as an investment to be maximized. The authors propose a distributed processing scenario which plans systems development and operations with the user and maintains a centralized MIS department for promulgating standards and procedures.

Woods, Larry D. : "Distributed Processing in Manufacturing," Datamation, Vol. 23, October 1977, pp. 60-63.

"Addresses the potential for the loss of control and the problems of maintaining corporate data bases in light of the proliferation of minicomputers in a large manufacturing company. Specifically, the environment of the John Deere Company and its approach to solving those problems are discussed." [from Quarterly Bibliography of Computers and Data Processing, Vol.7, no.4, January 1978.]

LIST OF THE ARTICLES SURVEYED

(1) Becker, Hal B., "Preparing for Distributed Data Processing", Data Comm User, January 1977, pp. 22-24.

(2) Becker, Hal B., "Six Steps to Network Analysis and Design", Data Comm User, March 1977, pp. 30-31.

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