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# Technology Architecture: Examining a Data Driven Model

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## Introduction

The 1990s has been marked by the widespread transfer of new information technologies that can alter the fundamental nature of computing. Effective storage and multitasking processing technologies have combined with developments in telecommunications to create new opportunities for resource sharing and communication among computers. The importance of this revolution has been recognized by senior information systems executives, whom have identified the planning and development of corporate information technology structure (architecture) as the most critical issue of the decade (Niederman , Brancheau & Wetherbe, 91). This study, through the responses of 313 North American senior IS executives, will explore the nature of IT (information technology) structure and its relationship to organizational structure.

## IT Structure

A critical step in empirically deriving a taxonomy is recognizing the salient dimensions of IT structure. The two elementary components are information technology and structure. Information technology has been historically defined in terms of its functions of processing, communication and storage (Bakopoulos, 1985). Structure has been determined, traditionally, by the degree of centralization of processing and the pervasiveness of networking (Leifer, 1988; Ahituv, Numann, Zviran, 1989). The task is then to develop a framework in which to meld these two accepted perspectives, while capturing the new emphasis in IS of sharing application programs and data.

The recognition of the centralization of processing as a dimension of IT structure would be an example of capturing both information technology and structure in a single dimension. The structural component of networking is related to both the functional aspects of communication and storage. A dimension that would capture the degree in which networked computers could communicate with each other would address both the network structure and communication capability of a system. The storage function of computers is the archiving of data and application program resources. The capability of networked computers to share stored data and application programs would be a dimension that would address the storage function and networking structure. This paper will empirically derive an IT structural taxonomy based on the following dimensions:

1.The extent that computer processing is centralized.
2. The degree that computers support communication.
3. The ability of computers to share data and application programs.

## IT and Organization Structure

The derived IT structure taxonomy will be examined by exploring its relationship to the organization's structural characteristics of integration and centralization of decision making. Organizational integration is the degree of interdepartmental cooperation within a corporation. Centralization of decision making is the extent that decisions (e.g. capital budgeting, pricing, personnel etc.) are focused at the top levels of the organization. Based on past research and theory, it is anticipated that the derived IT structural taxonomy (i.e. centralization of processing, degree of communication, sharing capability) will be related to organizational integration and decision making. (Ahituv et al., 1989; Huber, 1990;. Leifer, 1988).

Organizational integration should be facilitated by an IT structure that has the increased capability to share resources and support communication. Based on this observation, the first research proposition is: *The most integrated organizations will have IT structures have a greater capacity for communication and resource sharing.*

IT structure may have a complex relationship with organizational decision making. Huber (1990) has suggested that IT capabilities cause decentralized organizational structures to become more centralized and centralized organizational structures to become less centralized. Computer-assisted communication and shared data resources could inform leaders in decentralized environments, and be associated with more centralized decision making. However, in centralized environments, the same capabilities could empower lower level workers, and be related to less centralized decision making. This suggests that only those organizations that do not have IT structures could avoid the impact of the technology to move their organization toward the center. On another dimension, Ahituv, Neumann and Zviran (1989) found that the centralization of processing is directly related to the centralization of decision making. This is stated in the following second proposition: *Organizations with the most extreme decision making structures will have IT structures that are characterized by reduced capabilities for communication, application and data sharing and have corresponding extreme centralized or decentralization computer processing configurations.*

## Research Methodology

A random sample of nine-hundred organizations was chosen. Each organization's vice-president or director of IS was mailed a questionnaire. Forty-five surveys were returned because of invalid addresses and 313 were received for an effective response rate of 36.6%. A test for non-response bias was conducted by comparing the early and late respondents' answers, and no significant difference was detected in the variables used in this presentation.

## Validation Analysis

Construct validity of the measurement instrument for integration and centralization of organizational decision making was evaluated through factor analysis. The nine items, which consisted of a four-item scale for integration and a five-item scale for centralization of decision were evaluated through factor analysis. The constructs loaded as two distinct factors. The organizational centralization construct had an eigenvalue of 2.65 and an alpha coefficient of 0.77. The integration construct had an eigenvalue of 3.20 and an alpha coefficient of 0.91.

Cluster analysis was used to empirically derive the IT structural taxonomy. Cluster analysis is a multivariate technique for identifying similar entities. The first step in cluster analysis is to determine the number of clusters. One procedure for empirically determining the number of groups is the Ward Method of agglomerative hierarchical cluster analysis. Because this hierarchical cluster analysis is somewhat subjective, it is important to validate and examine the stability of the chosen clusters. Initial validation of grouping is carried out by determining that the four clusters are significantly different from each other using multivariate analysis of variance. Each of the groups' observed F statistic revealed differences significant at the 0.001 level. To gain further confidence in the chosen clusters, non-hierarchical cluster analysis, or K-means clustering, was used . To aid in the understanding of the categorization scheme, the total sample was divided into thirds to determine high, moderate and low average scores using a cutoff point that was calculated based on the normal deviate of a standard normal curve for each of the dimensions of the taxonomy. The next section will further discuss the results of the study.

## Results

The cluster analysis produced four IT structure types. The first IT structure is characterized by highly centralized processing, low communication and low data and application sharing capabilities. This structure would seem to be consistent with the characteristics of a *centralized computing environment*. The second group has dispersed processing with low communication, data and application sharing capabilities, which appears to be consistent with a *decentralized computing environment*.

The third classification has centralized processing, but high capabilities for communication, data and application sharing. The capacity for data and application sharing suggests that this system is much more than the hub and spoke computing structure proposed by Leifer (1988). A structure of centralized processing also indicates that this grouping was not anticipated by other typologies (Ahituv, et al. , 1989). Other typologies have predicted that the ability to share applications and data would be limited to dispersed processing environments and that cooperative computing would be an extension of distributed computing. Because this grouping appears to be an unanticipated type of cooperative computing, it is termed *centralized cooperative computing.* The last group is characterized by decentralized processing with high communication and sharing. This classification appears to be an extension of distributed computing, so it is termed *distributed cooperative computing.*

The widespread availability of new technologies in the 1990s appears to have altered the traditional distributed and hub and spoke computing environments by adding the ability to cooperate in the sharing of data and application resources, while the centralized and decentralized computing structures have remained relatively stable. The discovery of two distinct types of cooperative computing has significant implications for both researcher and practitioner.

Proposition 1 and 2 were examined by carrying out an analysis of variance to determine if the IT structures were significantly different in terms of integration and centralization of decision making. The assumption of homogeneity of variance was examined for the measurement of the integration using Levene's Technique, and after a power transformation of the data to stabilize variances was found to be valid. In the comparison of integration, the F values were significant at the 0.005 level for the IT structural groups (between groups/within groups: df = 3/288, Sum of Squares 1829.40/41417.88, Means Square 609.80/138.99, F= 4.3875).

Table 1 shows that the direction of the differences in integration for the IT structures is consistent with Proposition 1, however, not all of the integration scores are significantly different.

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| **Organizational Integration Table 1.** | Mean | Centralized Computing | Num. |
|---|---|---|---|
| Centralized Computing | 22.44 | | 80 |
| Decentralized Computing | 25.42 | | 50 |
| Centralized Cooperative Computing | 28.17 | * | 104 |
| Distributed Cooperative Computing | 28.18 | * | 68 |

* .05 Significance level determined using Turkey's HSD

Centralized computing environments have significantly less integration than do distributed or centralized cooperative computing environments (0.05 level of significance using Turkey's HSD analysis).

To examine Proposition 2, the assumption of homogeneity of variance was examined using Levene's Technique and was found to be valid for the degree of centralization of decision making of the IT structures. The F values were significant at the 0.001 level when the averages of decision making centralization for the IT structural groups were compared (between groups/within groups: df = 3/286, Sum of Squares 23.37/392.52, Means Square 7.79/1.33, F= 5.87).

Table 2 demonstrates that the mean centralization scores for the groups are in the order that is expected by the proposition. The IT structure with the highest centralization of decision making ( mean = 5.43) is the centralized computing environment. The centralized computing environment has centralized processing and a low capacity for communication and resource sharing. The IT structure with the most decentralized decision making structure (mean 4.60) is the decentralized computing environment. The decentralized computing environment has dispersed processing, but low capabilities for communication and resource sharing.

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| **Centralization of Decision Making Table 2.** | Mean | Decentralize Computing | Distributed Cooperative Computing | Num. |
|---|---|---|---|---|
| Decentralized Computing | 4.60 | | | 51 |
| Distributed Cooperative Computing | 4.91 | | | 66 |
| Centralized Cooperative Computing | 5.10 | * | | 102 |
| Centralized Computing | 5.43 | * | * | 81 |

* .05 Significance level determined using Turkey's HSD

## Conclusions

The four groupings of the derived IT taxonomy are exhaustive, mutually exclusive, stable and related to organizational structure. The groups consisted of: *centralized computing* (centralized processing and low communication and sharing), *decentralized computing* (dispersed processing and low communication and sharing), *distributed cooperative computing* (dispersed processing and high communication and sharing), and *centralized cooperative computing* (centralized processing and high communication and sharing).

The first proposition was partially supported. The direction of the mean organizational integration scores was consistent with the prediction. However, only the centralized IT structure was significantly less integrated than the two cooperative structures. The second proposition was supported. The most extreme decision making structures were associated with centralized and decentralized computing structures.

The most interesting IT structures may be those that have high capabilities for communication and resource sharing. These structures represent the current push to use modern IT for client-server computing systems. The commonly accepted nature of client-server computing would be captured in the distributed cooperative computing structure. However, the emergence of a centralized cooperative computing structure could have a variety of implications, especially since it has not been previously identified by other typologies and it is the most common IT structure (n=108; 35%) in the study. These findings, when considered with the recent emphasis on application and data sharing and the relative stability of organization structure (e.g. integration and decision making), may suggest that the centralized cooperative computing structure evolved from Leifer's (1988) hub and spoke structure.

Future researchers may wish to expand on the taxonomy developed in this study to determine if there are currently any additional dimensions necessary to refine the classification scheme. Further study is needed, through longitudinal or experimental research, to determine the existence and nature of the causal relationship between IT and organizational structures. As management is increasingly pressured to adjust organizational structures through downsizing, business process redesign, or developing new relationships with employees, customers, suppliers, and outsourcers, it is increasingly important to determine the role IT structure may have in enabling the successful fulfillment of organizational goals.

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