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A Framework for the Alignment of IT Architectures

with Information Processing Requirements of Organizations

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1. Introduction

The relationship between information technology and organizational structure has been widely studied in management information systems [Keen 1980, Robey 1981, Bakos and Kemerer 1992]. Both structure and IT have undergone significant changes in the last years and, accordingly, the consistency between choices along these two dimensions has regained attention.

The information processing perspective of organizational theory has conceptualized the relationship between organizational structure and information technology [Simon 1976, Galbraith 1973, Arrow 1974, Williamson 1975]. Under this perspective, organizations are attributed an overall information processing capacity (IPC) primarily as a consequence of their technical and structural choices. However, the concept of information processing capacity has never been adequately formalized in terms of operationalizable variables. The result is a scarcity of theoretical or empirical studies that demonstrate its applicability. Research aimed at revisiting the information processing perspective with a more practical orientation has been recently called for [Bakos and Kemerer 1992, Malone and Crowstone 1994].

We have taken the information processing perspective and defined two constructs, *sharing* and *customization*, as a link between organizational requirements and technical capabilities. In addition to the particular perspective, our approach has a more technical orientation with respect to other studies, aiming to support technical choices in the design of an IT architecture (see [IBM Systems Journal 1993] for a collection of representative works which consider the relationship between IT and structure at a more strategic level). In our research, we have defined a process model of organizations to formalize the constructs of sharing and customization and analyze their mathematical relationship with structure and IT architecture. In this paper, we focus on the practical implications of our approach, by briefly presenting these constructs and discussing a framework that illustrates their use.

2. Outlining the Framework

An accepted principle in the information processing perspective is that information exchanges must be coordinated for organizations to show an information processing capacity greater than the individuals composing them. However, while some of the literature emphasizes the need for seeking information (see, for instance, [Hedberg et al. 1976]), a significant number of authors focus on the risk of information overload (see, for instance, [Ackoff 1967]).

Both aspects can be recognized as necessary for coordinating information exchange. If the cooperation of multiple agents creates a need for communicating information, it also proves that any individual alone is incapable to process the whole volume of information. To overcome these limitations, we propose that information must not only be *shared* but also aggregated and *customized* to the requirements of individual agents. Accordingly, we have defined two determinants of information processing capacity. The first, called *sharing,* is the level of accessibility to other agents' information. The second, called *customization*, is the degree to which accessible information is filtered and tailored to individual requirements. Sharing and customization can be used to express both organizational requirements and information technology capabilities.

Let's consider an organizational process, made of different information processing tasks, mutually exchanging information. Sharing is high when tasks are highly interdependent with each other, that is, they exchange a quantity of information close to the total amount of information in input to the process. Conversely, customization will be tied to the characteristics of the individual tasks. When tasks show a high level of usage of their input information, they receive information suitable for their processing requirements, without being overloaded. We propose that the level of usage of input information is largely determined by task complexity. Complex tasks are characterized by high variety in information requirements and are likely to use and reuse information for different purposes.

From an IT perspective, sharing and customization can be defined on the basis of the fundamental architectural components, data and applications. Information *sharing* translates into the overall accessibility of data generated by different users. On the other hand, *customization* is represented by data access and usage through applications tailored to individual needs. By relieving users from a number of information processing activities, customization allows the access to large collections of data otherwise beyond the processing capabilities of any single individual.

Table 1 shows a grid which classifies processes according to their levels of interdependence and complexity. Since interdependence and complexity are tied to the required levels of sharing and customization, these can in turn be associated with a corresponding IT architecture. As explained below, the IT architecture is selected to minimize the cost of achieving given levels of sharing and customization. Other criteria, such as the openess of the resulting architecture, or the constraints imposed by legacy systems, could be considered, possibly reaching different conclusions. The analysis of these criteria is out of the scope of the present paper.

IT architectures are classified into four categories, each representing a different set of technical choices: centralized without database, centralized with database, decentralized and distributed. Centralized architectures without database make no distinction between data and applications. Data belong to the application creating them and are not integrated across different applications. Data common to multiple applications are generally duplicated, since applications do not easily communicate with each other. Centralized architectures relying on database technology permit the independent design of data and applications. Data common to different applications can be integrated and managed as a unified resource. In both cases, data and processing capacity are centralized.

Architectures are decentralized when individual users are assigned personal computing capacity located at their work site. They are distributed when these sites can communicate with each other and storage of data and execution of applications are allowed on any node. While in a decentralized architecture data are not integrated and have to be duplicated to be accessible from multiple sites, with distribution they can be integrated where necessary and made available to all sites in the architecture.

	Low task	**High task**

	Complexity	**Complexity**
Low task Interdependence	Centralized Without database	Decentralized
High task Interdependence	Centralized With database	Distributed

Table 1 - Correspondence between processes and IT architectures.

In a real case, the IT architecture is generally a hybrid, mixing features from all the categories above. For the sake of simplicity, here, the discussion is limited to these main cases. Making a distinction among these categories allows us to address some of the most common technical choices, such as the extent of data integration, the degree of hardware decentralization, the advantages of data duplication. The literature associates differential costs with the technical choices involved by these architectures (cf. [Ein-Dor 1985, Jain 1987, Bauer et al. 1994]). Among the most significant are:

communication costs, linked to data exchanges among different sites.

processing costs, linked to application processing.

storage costs, linked to permanent data storage.

overhead costs, linked to data integration and management.

The sum of these costs will be used to select the most advantageous architecture to meet required levels of sharing and customization. Note that this is not an exhaustive set of costs, as it excludes, for example, training and other management costs. However it is a sufficient baseline measure for comparing alternative architectures which afford similar levels of sharing and customization at varying costs. Table 2 compares costs in the different classes of architectures. The number of plus symbols in Table 2 is proportional to the cost incurred in different architectures to satisfy equal requirements for communication, processing, storage and overhead. Sharing can be recognized to increase the requirements for communication, storage and overhead, while customization would affect communication and processing costs.

	Communication Costs	Processing Costs	Storage Costs	Overhead Costs
Centralized without DB	++	++	+++	+
Centralized with DB	+	++	++	++
Decentralized	++++	+	+	+
Distributed	+++	+	+	+++

Table 2 - Cost comparison in different architectures.

When task complexity and interdependence are both low, centralized architectures without database involve the lowest cost. Low sharing *per se* involves low storage and communication costs. In these architectures, low levels of sharing can be obtained without integrating data across different applications, with minimal overhead and communication costs. Similarly, low customization involves low processing costs. When task complexity grows, higher customization can be reached at lower processing costs with downsized hardware resources in a decentralized architecture. Conversely, greater task interdependence requires higher sharing and, in turn, increased storage costs to duplicate data in different applications. A centralized architecture with database is more convenient as it increases overhead costs, but more significantly reduces storage costs by integrating data. Distributed architectures show higher communication and overhead costs, but they are advantageous to satisfy high sharing and customization requirements with low processing and storage costs.

3. Conclusions

Organizational and technical measures of sharing and customization provide a basis for aligning information processing requirements with processing capabilities. Different types of processes and architectures coexist in a real organization. An organization can be analyzed in terms of its key processes and the alignment between structure and IT architecture can be assessed accordingly.

We have proposed and verified in a case study operating definitions of sharing and customization which could be discussed in an extended version of this paper. We are now testing our model on a panel of 15 large Italian companies which participate in the *Observatory on IT investments and business strategies*, sponsored by MIP (the business school of Politecnico di Milano) and Politecnico di Milano. The purpose of this broader study is to verify the correspondence between processes and architectures proposed in Table 1. Further analysis which considers the performance implications of aligning IT and structure according to our framework is also being undertaken. We anticipate initial results at the end of the next semester and will have them available for presentation at the conference.

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