An Office Study: Its Implications on the Understanding of Organizations

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ABSTRACT

The results of an office study are presented. The goals of the study were to determine some parameters of the problem solving and knowledge level processing that occurs in a particular organization. The problem solving processes in the organization are described and the relationship between these problem solving processes and some characteristics of the knowledge used to solve the problems is discussed. In addition we describe the impact exceptions have on the evolution of the organization and identify two mechanisms that help the organization adapt to change. The implications of the results of the study on the understanding of organizations are discussed. Areas of further study are described.

1. Introduction

This paper is a descriptive report on an office study conducted by the author in the spring of 1983. The intent of the paper is to present a different view of the organization than is commonly in use in the office information system research community. The perspective taken is that the organization in a knowledge processing entity that solves problems, is goal oriented, and evolves.

The study was undertaken for several reasons. All too often I found myself having to *imagine* what transpires in offices because of the lack of good descriptions of office work. Most of the available descriptions do not contain enough semantic content of the office studied. Generally they contain information about the surface phenomenon in offices such as communication characteristics, document flow characteristics, or authority relations. In addition, it was time to investigate the applicability of some ideas relating organizational work and Artificial Intelligence (AI) (see [Barber, de Jong, Hewitt 83]) that had been proposed.

This paper will describe the organization studied, discuss some results of the study and suggest what implications these results have on the attempt to use computers to aid organizational work and on models of the organization. The conclusion of the paper is that there are definite problem solving activities that an organization exhibits and without an understanding of the organization as a knowledge processor and a problem solver office information system technology is limited in what it can do to increase organizational performance and effectiveness.

In beginning I would like to distinguish 2 ways machines may be used in organizations. In the first case machines can be used in an *operative* manner. This is the way most machines are used in organizations today. The machines are used to insure the operation of some function in the organization. Operative applications include document preparation systems, electronic mail systems, and data processing systems. In the second case machines may be used in a *cognizant* manner. Examples of cognizant applications would be: a system that could understand what a human user was doing or needed to do and perform some tasks that aided the user; or a system that could predict the consequences to the organization of an action, e.g., entering into a particular contractual obligation. Cognizant systems are systems that have a semantic understanding of the tasks performed and of the operation and capabilities of the organization.

One of the long term goals of this research is to determine ways in which computers can be used in a cognizant manner within the organization. It is the author's belief that at this time organizations are not well enough understood in terms of their problem solving processes and the relation between these processes and the knowledge used to solve problems. It is the goal of this paper to point out some of these processes observed in an organizational study.

2. Background

Past organizational theories that have attempted to characterize the decision making capabilities of organizations have started with the capabilities of the individuals that make up the organization. The Scientific Management theory treated the human in the organization as a rational being [Taylor 47]. The triumph of Scientific Management was its ability to describe the physical work of individual factory workers in terms of decomposable tasks and to give *optimality* conditions for the design of factory jobs. This work was later addressed using the techniques of Operations Research to develop a theory of the organization as a collection of individuals with optimal decision making capabilities. However is was not possible to apply Operations Research and the task description methods of Scientific Management to information based work. As was pointed out by March and Simon [March, Simon 63] members of organizations are not optimal decision makers and it is misleading to build an organizational theory based on this assumption. March and Simon proceeded to build a theory based on the assumption that individual's are of limited rational capacity and made decisions based on the notion of satisficing. This work was the foundations of the information processing view of the organization [Cyert, March 63, Galbraith 77].

The work reported on here is an extension of the ideas developed by these authors. The objective is to understand the organization as a knowledge processor and to understand how organizations can perform functions (e.g., writing tax legislation or building a 747) that require knowledge not given in its entirety to any single individual in the organization. In [Barber, de Jong, Hewitt 83] the authors distinguished information-action models of the organization from knowledge and problem solving models. They argued that *semantic support* of work in the organization is needed and that describing work in organizations in terms of goals and problem solving could more easily capture the character of organizational work.

In addition to the need to have a better way to describe organizational work other problems in the arena of office information systems will benefit from a view of the organization as a knowledge processor. Below are listed some of these problems that I believe could be more directly addressed using a knowledge processing approach.

* Currently there is no coherent framework within which designers may work to build office systems. The state of the art amounts to do's and don't's that have been derived from experience. A knowledge processing view of the organization can make explicit what information (formal or informal) is necessary for accomplishing a task. These dependencies and information about how individual and organizations actually solve problems can provide design guidelines for office system designers.

* Efforts at performance analysis of the organization have been discouraging. It has proved difficult to measure quantitative and qualitative data that is meaningful. It has proved difficult to even develop a reasonable definition of productivity. These difficulties stem from the fact that the organization is inherently a knowledge processing and problem solving entity. Therefore performance and productivity questions are questions about the knowledge processing and

problem solving capabilities of the organization. However, the current models in which these questions can be framed do not capture the notions of knowledge or problem solving.

* There are methodological problems in determining what organizational workers do. As a result most studies are limited to studying surface phenomenon such as use characteristics of telephone, copiers, graphics messages, etc. These studies result in a dangerous trend in the design of office systems today: "Our studies reveal that managers spend 80% of their time communicating. Therefore we have to give them more sophisticated communication capabilities."

In the following sections we point out the importance of a *rational basis for performance* in the functioning of the organization. This is the principle that each action taken or belief adopted by an entity (organizational or individual in an organization) during the process of achieving the entity's goals must be justifiable in terms of a negotiated set of rules and beliefs. This justification takes the form of an argumentation composed of the rules and beliefs. The justification of the acts taken by an entity in achieving goals in terms of an argumentation is a justification of the entity's problem solving activity. The knowledge used in deciding how to solve a problem is of central importance to this idea. Thus this is another motivation for understanding the organization as a knowledge processor.

The purpose of the study reported on here is to determine some of the problem solving characteristics of the organization. In effect the study has been more of a investigation to determine some coarse grain characteristics of problem solving in the organization. Future studies will be able to proceed in more detail based on the results of this study. The intent of these future studies will be to gather information that is qualitatively different from past studies. Information that relates directly to the semantics of the work, the structure of the task domain, and how the structure of the task domain helps determine the problem solving mechanisms used by the organization.

3. The Organization

In this section I give an overview of the organization within the European Economic Community that was studied. What the organization does and who makes up the organization is described.

3.1. An Overview

One of the many activities of the European Economic Community is to award financial aid to businesses in the european agriculture community. A rough train of events of how this happens is as follows:

1. A organization with capital improvements it would like to make applies for a grant.

2. The EEC awards a grant for the work, possibly with exclusions.

3. The recipient of the award executes the improvements.

4. The recipient submits a Payment Request describing the work performed and requesting

reimbursement.

5. The EEC examines the work performed and calculates the appropriate reimbursement.

6. A Payment Order is generated and the recipient is reimbursed.

The particular organization I studied was called a *cell* and was charged with the 5th and 6th steps described above. The cell receives payment requests, analyzes them, determines the appropriate reimbursement and generates the payment order.

The approach used to solve the problem of providing financial aid to organizations is a functional decomposition of the problem into subproblems. Sub-units in the organization (e.g., the cell) are charged with one or more of the subparts of the overall problem. We may not a few characteristics of the problem:

* Evidently the problem is static enough that its decomposition does not change radically over time. Thus static sub-units of the organization can be identified with subparts of the problem.

* Since the cell is charged with both the 5th and 6th steps described above the knowledge necessary to perform these two steps is probably strongly related.

* The knowledge necessary to characterize a particular case of financial aid must be relatively easy to formulate in comparison to the knowledge necessary to calculate the appropriate reimbursement since the first moves from one organizational subunit to another while the second is contained in a single subunit. For example, another way of solving this problem would be to assign a single entity (individual or organizational subunit) to handle all subparts of the problem.

The cell is composed of a 10 to 15 professional people with little clerical support (1 to 2 people). There were 3 layers to the organization of the cell. These correspond to the cell's supervisor at the highest level, the Heads of Language Groups (HLG) at the middle level and the reporters at the lowest level. The Coordination Committee is a committee that is made up of all the Cell Supervisors. Thus the structure is as depicted in figure 3-1.

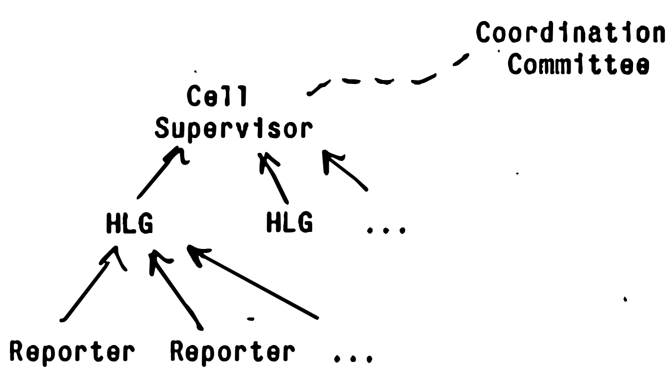

Figure 3-1: The Structure of the Cell

The specialization from the highest level to the middle level is by language. Each HLG directs a group of reporters that handle Payment Request in one language. The reporters under a HLG are given a Payment Request to process on an *as appropriate* basis. The HLG uses such criteria as workload, presence in the office and experience to determine who should be give a particular Payment Request. For example if a Payment Request is unusual but instructive the HLG may elect to give it to a relatively inexperienced reporter. On the other hand, if a particular Payment Request is complex in a particular way and a reporter is experienced with those particular complexities then a HLG would probably give the Payment Request to that reporter.

3.2. The Organization's Problem Solving Structure

The way the organization is structured gives insight into the way organization solves the problems that it faces. As described above the cell is part of a larger organization that has decomposed the problem of awarding grants into the subproblems of accepting grant proposals, choosing a selection of proposals and awarding grants, accepting payment requests and paying the awarded monies. The cell itself decomposes the problem of analyzing Payment Requests and generating Payment Orders into each language group and then on the "as appropriate" basis.

In going from the cell supervisor level to the HLG level we have a product decomposition verses a functional decomposition as seen in the example above. (For a more detailed discussion of product verses functional decomposition see for example [Simon].) Rather that breaking a problem up into a series of subproblems the approach used here is to *classify* a problem-instance as being of a particular type and give the problem to the specialist for handling that kind of problem. Evidently it is difficult for the problem solvers to handle a problem in any of the languages spoken in the European Economic Community. This is an example of the capabilities of the problem solvers affecting the structure of the problem solving mechanisms in the organization.

In going from the HLG level to that of the reporters the decomposition is at first appearance a product decomposition. It would appear that the reporters are a *pool* of resources and a case is given to any reporter that is free. This is only partially the case. The HLG uses his knowledge of the reporters' capabilities and his estimate of the difficulty of Payment Request to choose the appropriate reporter. In some cases he may choose a reporter skilled in the particular case (choosing a specialist), he may ask a reporter to do one section and another reporter to do another section (functional decomposition), or he may choose a particular reporter based on skill level. The HLG fulfills a coordination role with the purpose of maximizing his groups productivity. Some comments on the problem solving at this level are:

* The knowledge necessary to process a particular Payment Request if very case dependent.

* There is a wide range of difficulty in the cases presented to the cell.

* Each case is unique in that no common functional decomposition exists.

Thus there is a significant amount of uncertainty as to what the structure of any particular case will be. (Further discussion of the effects of uncertainty on organization structure can be found in [Galbraith 77, Fox 81].) For this reason the cell must be flexible enough to adapt to the various cases that it can be given. The source of this flexibility is the HLG, he uses knowledge of the type of case at hand and the capabilities of the reporters to perform an appropriate match between the Payment Request the the cell's processing capabilities.

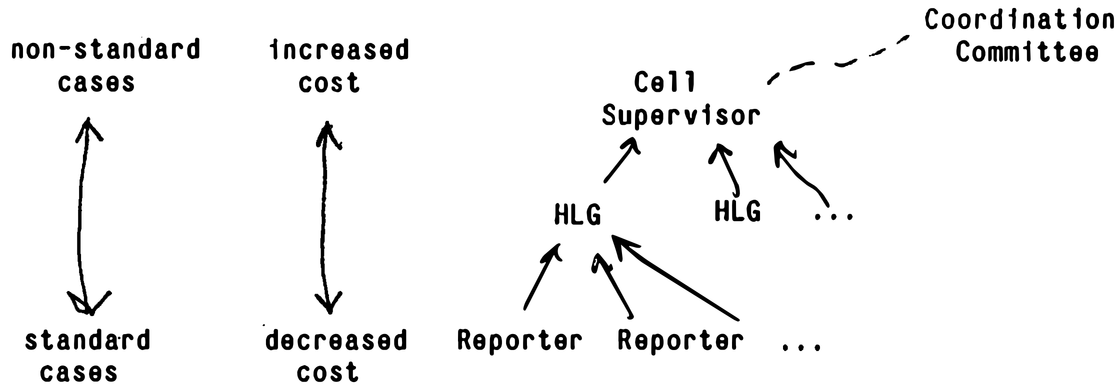

Figure 3-2: Observations on the Structure of the Cell

Some further observations on the problem solving characteristics of the cell in the case of exceptions are shown in figure 3-2. Typically when a Payment Request arrives it is routed to a reporter for handling. The reporters are specialist in the analysis of the Payment Request which is a complex task and involves the organization's rules and application of these rules in a narrow domain. Should the reporter have a problem with a Payment Request then he may consult a fellow reporter or the HLG. The HLG may make a decision on the Payment Request or ask the Cell Supervisor. If the Cell Supervisor is unsure of an appropriate solution or if the Payment Request is an interesting one, the Cell Supervisor will bring it before the Coordination Committee. Thus cases that are problematic move up the hierarchy to individuals that are more experienced, have a broader knowledge of the rules, and have a broader perspective vis-a-vis the organization's goals and policies. At the same time the cost of the individual increases as one goes up the hierarchy because more is required from the individual in terms of knowledge, experience and responsibility. We see that individuals at higher levels in the hierarchy have a dual role: they coordinate the activities of the individuals working beneath them and they solve the difficult cases that the reporters cannot solve because of limited perspective or experience.

Thus this structure can be seen as a way of achieving the organization's throughput and robustness requirements in a cost effective manner. The reporters are specialists in handling the commonly encountered cases thus being the major contributant to the Cell's throughput. The organizational level's above the reporter contribute robustness to the cell's performance. Although these levels may not be as proficient in processing the commonly encountered Payment Requests they are capable of handling the problematic cases.

The coordination committee is the focus of some very interesting activity. The coordination committee's responsibility is to resolve the problematic cases. There are 3 interesting aspects to the way the coordination committee resolves these cases.

* **Rule Generalization, Extension, and Formation** - The coordination committee analyzes the unusual case in light of the organization's rules and decides how those rules should apply. Frequently the rules don't apply in a easy manner. This requires some *bending* of the rules. It may be necessary to generalize a rule, extend a rule, make an exception, or make up a new rule to accommodate the case at hand. These changes to the rules used by the organizations are an *adaption* mechanism that allow the organization to adapt to minor changes in the environment or to its goals. If the committee is called on to justify its actions in resolving the case then it must have a rational basis for the action it took.

* **Consensus Forming** - Rule modification proceeds through a consensus forming process. Members of the coordination committee discuss how the organization's rules should apply to unusual cases. Each member has a conceptual model of the what the organization does from their own perspective. Usually one person's model will be more detailed in a particular area than another person's model. As proposals for rule application and modification are brought up, members of the committee can report undesirable implications of the proposals. The consensus process is both a method to debug proposed changes to rules and a way to share individual's models of the organization. (As a simplification I assume that the members of the committee share the same goals. The process becomes more interesting when members of the committee have conflicting goals.)

* **Evolutionary Adjustment** - The rules derived from the above processes and the problems in applying those rules are used to guide the evolution of the organization. For example if a particular class of problem appears frequently before the committee then a decision may be taken to create a new specialist's position (such as a new reporter) that is designed specifically to handle this class of problems. This is an example of a stronger adaption mechanism than the one described above. In this case the organization's problem solving structure is changed. This can allow the organization to adapt to major changes in its goals or in the environment.

From the perspective of the organization the committee performs two important functions, one internal and one external. Internally the committee insures that the organization has a consistent and meaningful set of rules by which to operate and that the organization meets its various requirements, e.g., throughput. Externally the committee insures that the organization presents a coherent interface to the outside world. For example, similar cases presented to the organization should produce similar results and not depend on internal organizational factors such as the case was handled in an English Language Group versus a French Language Group. The importance of this property is rather dramatically illustrated by this example: if it were not the case that similar cases produced similar results then this could be grounds for a political issue.

As is apparent from the above description the concept of rules is central to this view of the organization. There are many questions that arise: what is the structure of these rules, how are they applied, where are they, and how are they communicated? The relation between these rules and the AI concept of rules is beyond the scope of this paper and is a interesting area for future work.

From an AI point of view the different levels of the organization have a problem solving interpretation. The Payment Requests that are handled normally require little problem solving on the organizational level. Those that are difficult to handle move up the hierarchy until they can be resolved by more knowledgeable problem solvers. Thus the reporters and the tasks they performed are highly specialized or *compiled* activities. The intermediate levels--the HLG's and Cell Supervisor--are the levels most knowledgeable in application of the organization's rules. This might be called the reasoning component of the organization. Given the organization's accepted set of rules the individual's at this level decide how to apply the rules. The coordination committee represents that part of the organization that helps in the application and modification of rules and in guiding the evolution of the organization as a problem solving mechanism. It decides when the organization's problem solving structure must be modified. The knowledge and mechanisms necessary to perform this task are especially interesting to AI as they provide a kind of learning behavior.

4. The Individual's Work

In this section I will concentrate more on the problem solving activities of a particular individual, in this case a reporter. The major point of the section is to argue that the work of the individual is best described in terms of goals and accepted methods for achieving the goals. Here again we find that the notion of a *rational basis for performance* is important. The description of an individual's work as goals and accepted methods for achieving them is important from another standpoint: it localizes the decision making about exactly how a task is to be done (a goal achieved) with the individual performing the task. Thus this method of describing organizational work is an approach compatible with the decentralization of decision making.

A reporter's task is to receive a Payment Request, analyze it, calculate the appropriate reimbursement and generate a Payment Order. Reporters are professional level people that take about 6 months of on the job training before they become proficient at their tasks. There is a significant amount of flexibility and individual style in how they accomplish their work. When one begins to analyze the complexity of the domain one is struck by the large amount of information involved and the situation driven characteristics of the work. For the reporter many different situations give rise to different problem solving approaches. When analyzing the Payment Request if there is a difference between the work planned and what was actually done then this gives rise to one set of problem solving approaches. There are other rules and problem solving approaches if work extends beyond its scheduled completion date. If the Payment Request does not contain enough documentation of the work performed there are problem solving approaches which involve telephoning, requesting supplemental information or making site visits.

Past attempts to describe organizational work have often used some kind of procedural approach to specify what actions should occur and in what order. These approaches suffer from a variety of problems which have been documented elsewhere [Barber 82, Fikes, Henderson 80, Ellis 83] and are summarized here:

* In general these approaches are not practical. They are useful for giving a general idea of what the work may involve but in actual circumstances there are just too many possibilities to consider and too many circumstances that cannot be foreseen.

* A description of a task in a procedural fashion and a description of what actually happened in a particular procedure are very different and cannot be easily accommodated with one another.

* A procedural description approach, since it is composed of actions and decision points, does not give insight into why things are done.

* A procedural description approach does not provide a basis for exception handling or evolution.

As pointed out in [Kunin 82] a procedural approach in describing the work of individuals is problematic in situations where the work is flexible. This is the situation in the case of reporters. Procedural description approaches have given rise to the concept of "unstructured" work situations. This term is most frequently applied when describing the work of managers. However the work is unstructured insofar as the the structuring criteria used. The work managers and other office workers do is structured around the goals they have and the ways they have of achieving those goals.

The biggest mistake in using a procedural description approach is that because of their need for specificity they *remove the decision making from the decision makers that are most qualified and best informed.* Thus a goal based approach leaves it to the decision maker how exactly to achieve the goal and is a method to decentralize decision making and reduce the amount of information flow necessary in the organization. However, the decisions made must be accountable. Thus the decision makers must have a rational basis for their performance. In essence, when an employer hires someone the employer gives the employee some goals and methods for achieving the goals. Frequently, the employer accepts that the employee has some expertise and trusts the employee can use that expertise to achieve the employer's goals. By and large the employer doesn't care how the employee achieves those goals, just that the job gets done. The employee is free to make decisions within the realm of his expertise in the performance of the work but in the end the employee must be able to defend the work on a rational basis.

5. Conclusions and Future Work

From the above description of problem solving processes in the organization we can determine a number of characteristics of the organization's problem solving structure that help determine its effectiveness. Given a problem to solve then we consider the following:

1. The breadth of variations in problem instances.

2. The knowledge necessary to describe a problem instance.

3. The knowledge necessary to solve a problem.

4. The capabilities of the problem solving agents.

The problem solving effectiveness of an organization can be increased by increasing the organization's capacity to handle any one of these characteristics. In addition, flexibility along any of these dimensions allows for more flexibility in the design of problem solving structures in the organization. Consider the following hypothetical ways that the problem solving in organizations might be enhanced with the use of cognizant technologies:

* By aiding in the complexity of problem description. Knowledge structures can be used to describe a problem at a higher level of detail and more dynamically than what is feasible on paper for example. For example, interactions between subparts of problems can be more easily monitored and controlled.

* By bringing more knowledge to bear on problems being solved. The following techniques are applicable: quickly identifying problematic aspects, automatically processing routine cases, retrieving similar past cases, suggesting solution approaches, or analyzing solution approaches

* By adding problem solving agents. Cognizant machines could play a role in such tasks as classifying and delegating problems, decomposing problems into subproblems and coordinating the solving of subproblems.

A major obstacle to the above approaches is the limited understanding of what and how knowledge is used in organizations to influence the structure of problem solving and to solve problems. An implication of the study performed is that more understanding is needed in the area of knowledge processes in the organization: how is knowledge used to coordination the solving of processes, what knowledge is necessary to detect that a problem solving system is not performing satisfactorily, what knowledge is necessary to restructure a problem solving system, what kind of transformations occur to knowledge as it move in an organization, both laterally and vertically (eg, filtering, abstraction)?

Several other issues are implied as a result of this study. These questions provide be a basis from which to continue further work in this area.

In the preceding discussion I have not described the source of motivation. I have described what individual's do or what a committee does but have not described what motivates them to work in this direction. Presumably structural elements exists that can increase or decrease the amount of effort the individual or committee invests in achieving their goals. Common motivational mechanism's in human organizations are reward (salary and bonuses), competition, or strongly held values that derive from the organization's culture. Future work should address this issue as it is an important in explaining differing levels of dedication and achievement in the organization.

A more fine grained understanding of the goal structures in organizations and the relation of these structures to actions performed to achieve goals is needed. As outlined in [Barber 83] a goal of this research is to develop a workstation that can understand the goals of a particular process to aid constructively in achieving those goals. The workstation system would function as an assistant, noticing how goals had been achieved in the past, making suggestions for how to achieve goals and noting how solving new problems is different from past problems and understanding the reason for these differences. An understanding of goal structures in the office and the relation of actions to these structures would go a long way in achieving this workstation apprentice.

A key idea in this paper that surfaced as a result of the study is the notion of an argumentation or a rational basis for performance. There are many interesting questions relative to this idea that would be enlightening to answer. What does the idea entail, in what ways do organizations and people *rationally justify* what they have done? What is the relation between the rational basis for achieving a goal and what actually happened? What is a rational justification consist of, what kind of argument is it? For example, it is probably not a logical argument. What are the negotiation processes through which these argumentations are established as valid or invalid. Under what conditions are these arguments accepted?

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