TOOLS AND TECHNIQUES FOR ORGANIZATIONAL PROCESS DESIGN

(Extended Abstract)

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1. Introduction

Organizations need to rapidly adapt to changes in dynamic markets. The design of an organization can hinder or even prevent it from responding quickly to changes in its environment. The processes along with other resources in the organization drive its work and responses to changes in its environment. Processes of an agile organization must be effective, efficient, reusable and well managed. Furthermore, they must ease quick responses to changes in the environment of the organization.

The study of designing organizational processes can stimulate us to design better organizations. It can borrow ideas, tools and techniques from areas such as artificial intelligence, computer science, coordination science, logic and operations research.

Most of the activities performed in organizations deal with the processing of information to meet various goals. The design of an organization must support the primary activities that help the organization to achieve its goals. Information technology is providing new ways of organizing and performing activities. Transactions that required several hours of human attention can now be achieved in a few seconds. There are various kinds of communication facilities that have increased efficiency at reduced coordination costs. Information technology based tools are influencing the ways in which organizations perform their activities. Therefore, we need to design and re-engineer organizations taking advantage of new ways of performing organizational activities.

Two fundamental problems faced in the research area of computational organization design are representing knowledge and managing coordination activities. An organization achieves its goals by using its knowledge. Much of the activity in an organization has little to do with achieving the organizational goals. Instead, they support those activities that are performed to achieve the organizational goals. We can study the problems associated with representing knowledge and managing coordination from the perspective of organizational processes.

Following a process oriented view leads us to some important issues that ought to be addressed in the research area of computational organization design: 1) How can we represent organizational knowledge? 2) How can we model and manage coordination activities in an organization? 3) How can we find suitable representations for knowledge and coordination in a particular organization? A methodological approach to deal with these questions would be of great practical utility. It would also provide a framework for computational organization design and re-engineering.

In this paper, we highlight some tools and techniques from various disciplines. These

tools and techniques may enable us to study in detail the issues mentioned above. Furthermore, they can enrich the study of organizational processes and provide insights for designing organizations better.

2. Organizational Processes

An organizational process is a set of tasks that achieve particular goals of its organization. There are many kinds of processes within an organization. They affect all the work in the organization in some manner or other. Therefore, they deserve a great deal of attention during organization design. Unfortunately, their designs may remain stagnant throughout the life span of the organization.

Analyzing and redesigning the organizational processes may improve the performance of work in organizations. Adding the missing essential activities and deleting the present non-essential activities can improve the design of organizational processes. Optimizing the performance of a process design is a very challenging and interesting task.

Usually, it is possible to have more than one design for a process. It is only natural to choose the best process design to suit particular instances. Therefore, it is essential to have some means to differentiate between these process designs using various criteria. Each process has some inherent properties that can be used to evaluate its design. A set of processes may also have some other properties that may be used for categorizing them based on their similarities and specialties.

2.1. Complexity of Processes

Processes can be classified based on complexity, borrowing results in computational complexity theory. Let us define the *size* of a process as a function of its inputs. Then we can define the *complexity* of a process as a function of its size. The complexity of a process gives a bound for the resource requirements of the process for its termination. It is actually a measure of the fundamental activities it performs. Some processes are of polynomial complexity while others may be of exponential complexity. As the size of the process grows large, the number of fundamental activities performed by a process of exponential complexity grows very fast. We can also say that the processes of polynomial complexity require less effort and resources for completion than those of exponential complexity.

We can appreciate the notion of the complexity of an organizational process viewing it as a description of some cost associated with the process. For example, the fundamental activities may include the coordination actions the organizational process requires and/or performs to achieve its goal. At this moment, it is not very clear what constitutes a good measure for the complexity of an organizational process.

The complexity of a process is an inherent property. No amount of clever design can alter the complexity of a process. Although there is nothing that can change the complexity of a process, there are ingenious means to managing it. Knowing the complexity of a process is key to optimizing the performance of a process design in terms of time taken for its execution and other associated costs.

2.2. Similarities and Specialties

Similarities among activities in organizational processes can form another basis for categorizing them. Usually, there are several types of similar processes in an organization. Similar processes may also have special characteristics that differentiate one process from another.

For example, we may consider the advertisement process of an organization. The possibilities for advertising a new product may include resorting to media such as television,

radio, or newspaper. There are activities that are common to the processes of advertising in these media. There are also specialized activities in each of the advertisement processes. We can exploit such similarities and specialties of organizational processes to represent, analyze, improve and manage them [Ma93].

3. Representing Organizational Processes

Research in computer science and other disciplines during the last few decades has produced many approaches to representing processes. Flow charts, data flow diagrams, state transition diagrams, and directed graphs are some of the commonly used representations. A remarkable and distinct approach of Malone *et al.* represents processes at various levels of abstraction, using the concept of inheritance from computer science and ideas from coordination theory about managing dependencies [Ma93]. They use this approach to build an on-line library of organizational processes. This approach allows its users to explicitly represent similarities and differences among related processes. Furthermore, it can also help to analyze and improve existing processes and to design new organizational processes.

3.1. Inheritance and Specialization

Malone *et al.* make use of the inheritance property as in the object oriented paradigm commonly used now in programming [Ma93]. In the object oriented programming approach, increasingly specialized hierarchies contain objects. In contrast, they propose to develop a hierarchy of increasingly specialized processes. In their approach, generic processes are built from related processes. A generic process *decomposes* into sub-activities and *specializes* into more focused processes. These specialized processes inherit sub-activities and other characteristics of its "parent" process. The specialized processes may also add to or change the inherited characteristics. In addition to representing decomposition and specialization, there is also a way to specify precedence relationships among sub-activities in the process.

Malone *et al.* view coordination processes as ways of managing interdependencies between activities in a process [Ma93]. Using this view, it may be possible to characterize different types of interdependencies and to identify appropriate coordination processes for managing them. Then we can specifically indicate in the process representation, how an instance of a particular type of coordination process manages an interdependency.

3.2. Significant Benefits

There are several significant benefits in using the organizational process representation approach described in [Ma93]. First, it can help to invent new processes easily, if there is an available library of process models with various features. Furthermore, rapid and effective reconfiguration of organizational processes is easy for quickly adapting to changes. Second, if there is sufficient information on the organizational processes, redesigning them would be relatively easier than starting from scratch. Changes made at higher levels can transfer the properties and attributes down to the more specialized processes. Third, explicit representation of specialized processes can help to analyze their relative advantages and disadvantages, and to choose an appropriate alternative among the various options available. Fourth, the precedence relationships between the sub-activities in a process can help to analyze its correctness, efficiency, effectiveness, as well as timeliness.

4. Process Analysis

There are many tools being used for process analyses. The nature of the processes and the analysis affects the choice of the tool. In the following paragraphs we highlight a tool and a method for process analysis. Both of these are widely applicable.

4.1. Design Structure Matrix

The design structure matrix is a tool for representing structural information and relationships of a system [S81a & b, Ep91]. It can be used to capture the flow of information in any system, store the related information, and perform related computations. The rows and columns of this matrix show the tasks or parameters of the process. Entries in the matrix show the dependencies of a task or parameter upon another. Underlying the information in the matrix is a directed graph. The properties of this directed graph and other information in the matrix can be used for analyzing the process. They can also be used to sequence the activities in a process and manage other coordination activities a system requires. Viewing a process as a system, we can use the design structure matrix for its analysis.

Given a suitable representation of a process, we can model the process using the design structure matrix. Entries in this matrix indicate interdependencies between the tasks or parameters involved. If task ***a*** does not depend on task ***b***, then the entry at location [a, b] in the matrix takes a zero value. Otherwise, it takes a non-zero value.

The design structure matrix and the process representation model of Malone *et al.* can complement each other. Both these representations are suitable for different types of analyses. We can perform numerical as well as non-numerical computations, and related analyses on the design structure matrix.

A typical application of the design structure matrix is to find a near-optimal sequence for the tasks, subject to various constraints. If the length of each task in the process is known, we could try to sequence the tasks to minimize the total duration of the process. Considering the underlying structure of the matrix, we could find how to group together the agents performing the tasks to minimize coordination costs while increasing opportunities for communication between them. Such computations are very useful for managing design projects. Recent works using design structure matrices show that they are very useful in studying instances of design processes.

4.2. Correctness of Processes

Once the activities in a process are sequenced, we can test the correctness of the design of the process [Ha87]. Proving correctness of a process design is not always easy. It involves two steps, namely proving partial correctness and termination. Its basic element is choosing checkpoints in the process design. Checkpoints consist of start and stop points, and sufficiently many intermediate locations, so that each loop contains at least one checkpoint. Assertions can be attached to various intermediate checkpoints and their invariance can be confirmed by proving their local properties. Termination of processes can be proved by using checkpoints and showing convergence of some quantity depending on the process variables and representations. Determining the right checkpoints and proving correctness of process design require careful attention.

5. Summary

In this paper, we briefly highlighted some tools and techniques that, we consider, are of importance to the study of designing organizational processes. They provide a firm foundation for designing better organizations.

We speculate that the knowledge of process complexity is useful for developing better organizational process designs. We can draw upon results in computational complexity theory for this purpose. In computational complexity theory, the common trend is to consider resource requirements such as time and space. In the study of organizational processes, we believe that it would be beneficial to consider other factors such as coordination costs and related communication costs.

We do not know at this point in time what constitutes a good measure of complexity for the organizational processes. The process complexity should serve as a universal basis for comparing processes. The kind of the technologies used for managing communication and coordination of a process should not alter its complexity.

The formal techniques applied in computer program development are useful to analyze the correctness of organizational processes. Those methods can also help to improve the efficiency and effectiveness of each task in a process.

The design structure matrix can help to manage interdependencies between the tasks in a process. We have found it to be very useful in studying design processes.

The approach of Malone *et al.* provides an elegant representation for organizational processes. This approach is being used to develop an on-line handbook for organizational process. The process representation approach of Malone *et al.* and the design structure matrix are very useful for representing knowledge on organizational processes and managing coordination.

We need to develop a science base for studying organizational design. A systematic approach to designing better organizations should be of great practical utility. The study of designing better organizations will benefit from further developments in representing knowledge and managing coordination.

References

[Ep91] Eppinger, S.D. "Model-Based Approaches to Managing Concurrent Engineering," International Conference on Engineering Design, Zurich, August 1991.

[Ha87] Harel, D. *Algorithmics : The Spirit of Computing*, Addison-Wesley, Reading, MA, 1987.

[Ma93] Malone, T.W., Crowston, K., Lee, J., and Pentland, B. "Tools for Inventing Organizations: Toward a Handbook of Organizational Processes," 2nd IEEE Workshop on Enabling Technologies Infrastructure for Collaborative Enterprises, 1993.

[S81a] Steward, D.V. *Systems Analysis and Management: Structure, Strategy and Design*, Petrocelli/McGraw-Hill, NY, 1981.

[S81b] Steward, D.V. "The Design Structure Matrix: A Method for Managing the Design of Complex Systems," IEEE Trans. Engineering Management, August 1981.