

A Formal Approach to Workflow Analysis

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Abstract

A variety of software systems have been developed to aid in the structuring and implementation of workflow systems, but they are mostly visualization tools with few analytical capabilities. For example, they do not allow their users to easily determine which information elements are needed to computer other information elements, whether certain tasks depend on other tasks, and how resource availability affects information and tasks. Analyses of this type can be performed by inspection, but this gives rise to the possibility of error, especially in large systems. In this paper, we show how a mathematical construct called a metagraph can be used to represent workflows, so that such questions can be addressed through formal operations, leading to more effective design of organizational processes.

1. Introduction

Most organizations have traditionally been organized by function, such as purchasing, manufacturing, marketing, engineering, and accounting. This practice continues: human, physical, and financial resources are often managed by function, and most coordination is intra-functional rather than inter-functional. However, many organizations are finding that they must also manage processes – such as order fulfillment, new product introduction, and inter-organizational supply chain management – that span their separate functional units and that integrate their activities with those of other organizations. These processes are essential to the well being of organizations in a dynamic competitive environment ([5], the development of models of business processes [4].

Processes must be adapted to specific circumstances, such as inventory outages or negative responses to new products. The specific collection of tasks, resources and information elements involved in each such circumstance

comprise a workflow¹. Several persons will be involved in the management of processes and their workflows ([8], [15], [9]). Senior executives need to understand what information elements are required and produced by a process and what resources are needed. Process managers need to understand how the tasks in each workflow interact with each other through the information elements they use and produce. Information technology managers need to understand how information elements, tasks, and resources interact, so that effective operational and decision support systems can be designed. This suggests a need for modeling processes in a way that facilitates identification and analysis of their component workflows.

Processes and their associated workflows can be modeled in several ways using different tools. Four perspectives commonly used in process representation are as follows [11]:

1. *Informational modeling* focuses on the informational entities involved in the process, the structure of these entities and their interrelationships.
2. *Functional modeling* focuses on what tasks are being performed, and what informational elements are involved in these tasks.
3. *Organizational modeling* focuses on what agents/resources are involved in each task, where information entities are stored, and what communication is needed between agents/resources.
4. *Transactional modeling*² examines issues of timing (sequencing) and control, both within and between the tasks involved in the process.

Traditionally, these perspectives have been implemented separately. A significant contribution of our approach is that it integrates the informational, functional, and organizational perspectives within a single model. This allows not only graphical visualization of processes, but also their formal analysis, since the model is based on a powerful graph-theoretic construct, a metagraph. This construct extends the features offered by traditional graph structures such as digraphs and hypergraphs, and allows us to address questions such as the following using algebraic operations on metagraph representations of processes:

1. How do information elements relate to each other through the tasks that use and produce them – for example, which information elements are

¹ A more restricted definition limits workflow to only automated activities in a process [9].

² [21] uses the term “behavioral modeling” for this perspective, but we feel that “transactional modeling” is more representative.