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Workflow structuring and reengineering method for design process

Heejung Lee *, Hyo-Won Suh

Department of Industrial Engineering, Korea Advanced Institute of Science and Technology (KAIST), 373-1 Kusong-dong, Yusong-gu, Taejon 305-701, Republic of Korea

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Abstract

A short lead time for product commercialization is a critical advantage in the era of highly challenging competitions. It is more difficult, however, to shorten the design process rather than manufacturing process since the underlying design activities in process and related data are often interlinked and quite uncertain, and the attempts to perform the design activities concurrently increase the complexity of the design process.

In case the targeting process is well-structured and easy to be managed, many approaches have been proposed and it is the best way to use the well-known reengineering method such as crashing the bottle-neck activity. However, they have only concerned mainly about well-defined procedures, not an operational-level sophisticated workflow.

As a means to effectively manage and accelerate the design process, a process or workflow model needs to define complex relations such as iteration or coupled dependency in design process in order to coordinate the sophisticated process effectively. And, the acceleration approaches based on the operational-level information needs to be discussed.

Firstly, in order to develop an appropriate model that effectively captures the operational-level characteristics in design process, we define the workflow including the control and data flow with an incidence matrix called Workflow Matrix (*WfM*). Secondly, a workflow structuring method is developed for identifying the reengineering issue and it also transform the complex design process into a well-structured workflow. Finally, we analyze the design process with *WfM* and suggest reengineering strategies to improve the design process.

Keywords: Design process; Workflow; Reengineering

1. Introduction

Today's competitive market has created a highly challenging environment for product commercialization. Companies strive to offer high quality products to markets at a lower price and in shorter time. They are now required to develop a well-structured development plan to organize their processes and information flows, and consequently to reduce design process lead time. Developing such plan requires understanding the characteristics of design process.

* Corresponding author. Tel.: +82 42 869 3123; fax. +82 42 869 3110.
E-mail addresses: ssol@kaist.ac.kr (H. Lee), hw_suh@kaist.ac.kr (H.-W. Suh).

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Design process involves specifications of many activities, which together define a sophisticated workflow. These activities also define how the process is performed and what it produces and requires. A large number of decision makings are included in them and they demand creative thinking, experience, intuition, and quantitative analysis. The decisions or activities are to be driven by certain input data and to produce some output data to meet functional specifications. In design process, these activity flows contain iteration, which means that, for example, data A cannot be determined unless data B is first known or assumed, but data B cannot be determined unless data A is first known or assumed. These iterations are wasteful if they can be eliminated without losing values or causing failure to complete the design process. Deciding precisely what iteration can be thus eliminated is the matter left for empirical research. Informal surveys have revealed an estimate that as high as 50% of design time is spent on needless iteration (Ballard, 1999).

Iteration is a fundamental characteristic of design process, and the reengineering of design process should be focused on the iteration management that requires a deep understanding of activity flows and related data. Many researches have focused on reengineering of general processes. What seems to be lacking in the traditional approach, however, is structural reengineering framework that supports the complex and unstructured characteristics in the design process. Applying the reengineering policy to the design process demands an appropriate workflow model that captures its characteristics effectively. To overcome this situation we propose workflow structuring methods based on the suggested workflow model called Workflow Matrix (*WfM*) and also suggest the workflow reengineering methods to improve the design process.

1.1. Related works

Coupled activities are mainly responsible for the design process iterations. They represent the conflicts in the data flow and resolving such conflicts requires the engineers to iterate their tasks through trial and tactic knowledge until an acceptable design specification is met. The problem of managing design process iterations was first introduced by Steward (1981), who describes how to plan design process by analyzing the data flow embedded in the design of a given product. Using a binary matrix to capture the data flow structure of design process, Steward concentrates on the design cycles to decouple a design process. He also maintains that the design activities must be ordered completely, ideally yielding a cycle-free graph presentation to plan the design process. However, the overall objectives in Steward's proposed procedure remain ill-defined, so Smith and Eppinger (1997a, 1997b) extend Steward's work by investigating different strategies for managing design process to reduce the overall process time and improve the quality of the design decisions. In the first model, they employ work transformation matrix to identify controlling features of iteration in a coupled design process. In the second model, they introduce several approaches to capturing development time to evaluate the effectiveness of different arrangements of activities. Kusiak and Wang (1993) develop an algorithm for organizing design activities in order to effectively produce an acceptable design specification. The relationship among design activities is represented by an incidence matrix and the corresponding directed graph. While this literature greatly advances the understanding of managing design process, they do not consider main characteristics of practical design process such as activity precedence, information dependency, and resource management.

To shorten the lead time, many researchers have enumerated several intuitive principles of accelerating the design process (Handfield, 1994; Krishnan, 1996; Millson, Raj, & Wilemon, 1992; Rolstadas, 1995; Ulrich & Eppinger, 1995; Zirger & Hartley, 1996). In their studies, methods such as crashing, parallelizing, and overlapping were mainly discussed for reducing the lead time of the design process. On the other hand, Kusiak, Larson, and Wang (1994) proposed a detailed reengineering approach. They described six basic patterns of design process and qualitative methods to improve each pattern. They claimed that the improvement could be realized by managing critical activities better in each modeling pattern or by upgrading worse patterns to better patterns with heuristic rules.

Although many approaches have provided several modeling and reengineering methods for improving the design process, most approaches do not provide any systematic guideline from the modeling the design process at an operational-level to the suggesting how to apply the reengineering strategies to the design process.