Chapter 25
Engineering Design Knowledge Management

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Category: Application-Specific Knowledge Management

INTRODUCTION

In recent years, greater global competition is pressuring organizations to produce industrial products with the shortest possible lead times, high quality, and lowest costs. The lifecycle of a product includes many phases such as requirement definition, conceptual design, production, operation, maintenance, and so forth. Each phase in the lifecycle would involve the product information, for example, using some information that comes from other phase(s) and generating some new information during the phase. Engineering design knowledge (EDK) of a product consists of the product information related to the design process of the product.

It should be noticed that modern products are complex, and their developments have increasingly become collaborative tasks among teams that are physically, geographically, and temporally separated (Caldwell et al., 2000; Szykman, *Sriram, Bochenek, Racz, & Senfaute*, 2000). As design becomes increasingly knowledge intensive and collaborative, traditional design databases, which merely provide access to schematics, computer-aided design (CAD) models, and documentation, are inadequate for modern product design (Szykman et al., 2000), and the need for computational design frameworks to support the representation, integration, maintenance, and use of knowledge among distributed designers becomes more critical. The *representation*, *integration*, *maintenance*, and *use* of knowledge consist of the knowledge management of engineering knowledge.

BACKGROUND

Nowadays most engineering design is a knowledge-intensive process undertaken by teams dispersed across multiple disciplines. So it needs to be supported with relevant engineering design knowledge. We call *engineering design knowledge* all the standards, laws, and best practices that need to affect the design decision. Engineering design knowledge attempts to integrate three fundamental facts of artifact representation: the physical layout of the artifact (*structure*), an

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indication of the artifact's overall effect (*function*), and a causal account of the artifact's operation (*behavior*) (Szykman et al., 2000). The function-behavior-structure (FBS) engineering design model has been developed in Tomiyama, Umeda, and Yoshikawa (1993) and Tomiyama, Mantyla, and Finger (1995). Based on the model, four categories of design knowledge were basically classified (Li & Zhang, 1999): *artifact functions*, *artifact behaviors*, *artifact structures*, and the *causalities* among structures, behaviors, and functions. Function knowledge is about the purpose of an artifact; behavior knowledge is about the changes of states of an artifact; structure knowledge is about a set of components and their relationships; causality knowledge is about design constraints, wishes, physical principles, heuristic rules, and so on.

Corresponding to contemporary engineering design, engineering design knowledge is *structured*, *distributed*, and *evolving*. It is generally already formal or can be easily formalized. It essentially consists of sets of constraints with additional references, justifications, illustrations, examples, and other documentation. This knowledge lends itself to a formal, machine-readable representation. Engineering design knowledge is typically distributed because most engineering artifacts involve a variety of domains of expertise (e.g., electrical, mechanical, styling, and manufacturing) and a variety of stakeholders (e.g., manufacturers, suppliers, servicing agents, legislators). The knowledge is distributed in the sense that each area of expertise and each stakeholder authors, publishes, and maintains their own repository. The SAE (Society of Automotive Engineers) handbook and EPA (Environmental Protection Agency) publications, for example, are published and updated independently of each other. Finally, the knowledge is rapidly evolving because it is meant to be a live reflection of the state of the art and the state of the technology relevant to the engineering domain of interest. The knowledge gets updated asynchronously, and the updated information is made immediately available to the user.

Because engineering design knowledge has a large size, rapid pace of growth and evolution, and distributed ownership, it is better managed as an independent resource rather than hard-coded within the CAD systems or their satellite tools. The management of the engineering knowledge entails its modeling (representation), maintenance, integration, and use.

ENGINEERING DESIGN KNOWLEDGE MANAGEMENT

The management of engineering design knowledge entails its modeling (representation), maintenance, integration, and use. Knowledge modeling consists of representing the knowledge in some selected language or notation. Knowledge maintenance encompasses all activities related to the validation, growth, and evolution of the knowledge. Knowledge integration is the synthesis of knowledge from related sources. The use of the knowledge requires bridging the gap between the objectives expressed by the knowledge and the directives needed to support the designer in creating valid engineering artifacts. The management of engineering design knowledge requires an adequate modeling language and an associate inferencing mechanism. So in this short article, we only focus on the modeling of engineering design knowledge.

Knowledge Modeling

Knowledge modeling and the representation of structural information have been prominent issues in artificial intelligence, knowledge representation, and advanced applications of databases. Although the design knowledge representation itself is not a new subject, there is no commonly agreed approach to the problem, and it still represents an active area of research (Vranes & Stanojevic,

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