Chapter 4.16
Engineering Information Modeling in Databases

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INTRODUCTION

Computer-based information technologies have been extensively used to help industries manage their processes and information systems become their nervous center. More specifically, databases are designed to support the data storage, processing, and retrieval activities related to data management in information systems. Database management systems provide efficient task support and tremendous gain in productivity is thereby accomplished using these technologies. Database systems are the key to implementing industrial data management. Industrial data management requires database technique support. Industrial applications, however, are typically data- and knowledge-intensive applications and have some unique characteristics (e.g., large volumes of data with complex structures) that makes their management difficult. Product data management supporting various life-cycle aspects in the manufacturing industry, for example, should not only to describe complex product structure but also manage the data of various life-cycle aspects from

design, development, manufacturing, and product support. Besides, some new techniques, such as Web-based design and artificial intelligence, have been introduced into industrial applications. The unique characteristics and usage of these new technologies have created many potential requirements for industrial data management, which challenge today's database systems and promote their evolvement.

BACKGROUND

From a database-technology standpoint, information modeling in databases can be identified at two levels: (conceptual) data modeling and database modeling, which results in conceptual (semantic) data models and logical database models. Generally, a conceptual data model is designed, and then the designed conceptual data model is transformed into a chosen logical database schema. Database systems based on logical database models are used to build information systems for data management. Much attention has been directed at conceptual

data modeling of industrial information systems. Product data models, for example, can be viewed as a class of semantic data models (i.e., conceptual data models) that take into account the needs of engineering data. Recently conceptual data modeling of enterprises has received increased attention.

Generally speaking, traditional ER/EER (Entity-Relationship/Extended Entity Relationship) or UML models in the database area can be used for industrial data modeling at the conceptual level. But limited by the power of the aforementioned data models in industrial data modeling, some new conceptual data models such as IDEF1X and STEP/EXPRESS have been developed. In particular, to implement the share and exchange of industrial data, the Standard for the Exchange of Product Model Data (STEP) is being developed by the International Organization for Standardization (ISO). EXPRESS is the description method of STEP and a conceptual schema language, which can model product design, manufacturing, and production data. EXPRESS model hereby becomes a major one of conceptual data models for industrial data modeling. Much research has been reported on the database implementation of the EXPRESS model in context of STEP, and some software packages and tools are available in markets.

As to industrial data modeling in database systems, the generic logical database models, such as relational, nested relational, and object-oriented databases, have been used. However, these generic logical database models do not always satisfy the requirements of industrial data management. In nontransaction processing, such as CAD/CAM (Computer-Aided Design/Computer-Aided Manufacturing), knowledge-based system, multimedia, and Internet systems, most of the data-intensive application systems suffer from the same limitations of relational databases. Some nontraditional database models based on the aforementioned special, hybrid, or extended database models have been proposed accordingly.

MAJOR ISSUES AND SOLUTIONS

Conceptual Data Models

Much attention has been directed at conceptual data modeling of engineering information (Mannisto, Peltonen, Soininen, & Sulonen, 2001; McKay, Bloor, & de Pennington, 1996). Product data models, for example, can be viewed as a class of semantic data models (i.e., conceptual data models) that take into account the needs of engineering data (Shaw, Bloor, & de Pennington, 1989). Recently, conceptual information modeling of enterprises such as virtual enterprises has received increasing attention (Zhang & Li, 1999). Generally speaking, traditional ER (P. P. Chen, 1976) and EER can be used for engineering information modeling at conceptual level. But, limited by their power in engineering modeling, some new conceptual data models have been developed.

IDEF1X is a method for designing relational databases with a syntax designed to support the semantic constructs necessary in developing a conceptual schema. Some researchers have focused on the IDEF1X methodology (a thorough treatment of the IDEF1X method can be found in Wizdom Systems, 1985). The use of the IDEF1X methodology to build a database for multiple applications was addressed in Kusiak, Letsche, and Zakarian (1997).

As mentioned earlier, STEP provides a means to describe a product model throughout its life cycle and to exchange data between different units. STEP consists of four major categories, namely, *description methods*, *implementation methods*, *conformance testing methodology and framework*, and *standardized application data models/schemata*. EXPRESS (Schenck & Wilson, 1994), being the description methods of STEP and a conceptual schema language, can model product design, manufacturing, and production data, and the EXPRESS model hereby becomes a major conceptual data model for engineering information modeling.

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