

# Chapter XLVIII

## Ontology–Based Semantic Models for Databases

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### INTRODUCTION

A key characteristic of database systems is the layered structure and the accomplished independencies as is defined in the ANSI SPARC database reference model. This level-wise approach is also applied in the database development processes. According to the design triangle, the problem area to be mapped into the database is described by a human-oriented description at the initial phase of the design activity. Semantic data model (SDM) as a design tool uses concept-level elements in contrast to database schemas that are models at

the logical and physical levels. The main role of semantic models is that they provide an abstract approach; they are easy to understand and they provide database independence.

There are different application areas for semantic models. An SDM can be used for example in

- database schema design,
- knowledge transfer,
- database integration,
- schema validation, and
- knowledge representation.

In the history of database systems, several SDM models were proposed and used, such as the ER, IFO, ODL or UML models. Most of these models are strongly related to the underlying logical models and can not provide the required independency and generality. A new approach to create an efficient SDM for databases is the application of ontology-based description. According to our experiences, many experts on database management field are not aware of meaning of ontology. The aim of this article is to show and to explain the importance and role of ontology in design processes.

## SEMANTIC MODELS

With a formal definition (CROSI, 2005), the database schema model  $\Lambda$  can be given as a tuple  $\Lambda(\Sigma_\Lambda, P_\Lambda)$ , where  $\Sigma_\Lambda$  is the structure (or signature) and  $P_\Lambda$  is the integrity component. The  $\Sigma_\Lambda$  component is built up from predefined structure elements. Taking the relational model as an example for  $\Lambda$ ,  $\Sigma_\Lambda$  contains the following elements: field (attribute), relation and database signatures.

For a given  $\Sigma_\Lambda$ , the set of corresponding schema instances is denoted by  $I_{\Sigma_\Lambda}$ . An instance of a relational schema signature is usually given as a set of relation instances. The  $P_\Lambda$  component contains elements to define integrity constraints on the  $I_{\Sigma_\Lambda}$  set. An integrity rule is used to restrict the valid, permitted schema signature instances.

One of the earliest and most widely used SDM tools are the Entity-Relation (ER) and the Extended Entity-Relation (EER) models (Chen, 1976; Date, 1995). The main building blocks are entities, attributes and relationships. Entities can be considered as high-level structured concepts while attributes are the low-level atomic, or structured concepts. The EER model distinguishes three types of relationships: specialization among entities, encapsulation among entities and association between entities or attributes. In contrast to the structure oriented approach of EER, functional semantic models, like the IFO (Abiteboul, 1987) model, are based on global conceptualization. The IFO model provides a higher level of abstraction as it neglects logical schema elements like cardinality and some other integrity constraints. The ODMG ODL (Cattell, 1997) model is used to describe object

Table 1. Semantic data models

Semantic Model	Signature elements	Integrity elements
EER	Entity Attribute Structure Relationship (association) Specialization	Key Cardinality of association Multiplicity of values
IFO	Concept (entity) Printable element (attribute) Structure Association (function) Specialization	Key Cardinality of association
UML	Class (entity) Data type Field (attributes) Structure References (association) Methods Specialization	Key Cardinality of association Visibility of the elements

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