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Chapter I

A Constraint Based Fuzzy Object Oriented Database Model

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Abstract

The objective of this chapter is to define a fuzzy object-oriented formal database model that allows us to model and manipulate information in a (true to nature) natural way. Not all the elements (data) that occur in the real world are fully known or defined in a perfect way. Classical database models only allow the manipulation of accurately defined data in an adequate way. The presented model was built upon an object-oriented type system and an elaborated constraint system, which, respectively, support the definitions of types and constraints. Types and constraints are the basic building blocks of object schemes, which, in turn, are used for defining database schemes. Finally, the definition of the database model was obtained by providing adequate data definition operators and data manipulation operators. Novelties in the approach are the incorporation of generalized constraints and of extended possibilistic truth values, which allow for a better representation of data(base) semantics.

Introduction

In this chapter, a formal object-oriented database model that is suited to model both perfect and imperfect information is built. This model distinguishes itself from existing fuzzy object-oriented models by integrating (generalized) constraints (Zadeh, 1997). These constraints are used to define the semantics and integrity of the data and to define query criteria. Another novelty is its underlying logical framework of extended possibilistic truth values (de Tré, 2002). Moreover, the model is built upon the Object Data Management Group (ODMG) data model (Cattell & Barry, 2000), as far as its crisp components are considered.

The starting point for the formalism is an algebraic foundation, in which sets of objects, operators on these sets, and constraints that are defined for these sets are central (de Tré, de Caluwe, & Van der Cruyssen, 2000). Special domain-specific elements that are represented by the "⊥" symbol, are used to formalize "undefined" (or inapplicable) data. This foundation is formally defined on the basis of a type system and a constraint system. Starting from this basis, object schemes and database schemes are defined, which allow for databases to be defined rather easily. Furthermore, querying is generalized to a manageable closed set of operators.

Contrary to existing proposals that extend a crisp model, an approach based on generalization allows databases to be defined that handle perfect data as special cases of imperfect data. For the generalization, fuzzy set theory and possibility theory are used. Moreover, with the presented work, it is shown how Zadeh's theory on fuzzy information granulation and generalized constraints (Zadeh, 1996, 1997) can be applied within the context of a database model.

The underlying logic of the database model is many valued and uses so-called extended possibilistic truth values (de Tré, 2002), which are obtained by considering the three truth values — "true," "false," and "undefined" — and adding possibilistic uncertainty. This logic allows for a more epistemological modeling of truth and, moreover, can explicitly handle those cases where some of the data are not applicable.

The remainder of the chapter is organized as follows. In the next section, an overview of different approaches in fuzzy object-oriented database modeling is given. Furthermore, some preliminary concepts and definitions are introduced. In the section entitled, "Types and Type System," a type system, which supports the formal definition of all data types defined in the database model, is presented. These data types are compliant with the ODMG data model, as far as their crisp counterparts are considered. In "Constraints and Constraint System," a constraint system supporting the formalization of constraints is defined. Constraints are important for defining database semantics and query criteria. In "Object