



Chapter V

Fuzzy Information Modeling with the UML

Zongmin Ma
Université de Sherbrooke, Canada

Abstract

Computer applications in nontraditional areas have put requirements on conceptual data modeling. Some conceptual data models, being the tool of design databases, were proposed. However, information in real-world applications is often vague or ambiguous. Currently, less research has been done in modeling imprecision and uncertainty in conceptual data models. The UML (Unified Modeling Language) is a set of object-oriented modeling notations and is a standard of the Object Data Management Group (ODMG). It can be applied in many areas of software engineering and knowledge engineering. Increasingly, the UML is being applied to data modeling. In this chapter, different levels of fuzziness are introduced into the class of the UML and the corresponding graphical representations are given. The class diagrams of the UML can hereby model fuzzy information.

Introduction

One of the major areas of research in databases has been the continuous effort to enrich existing database models with a more extensive collection of semantic concepts. Databases have gone through the development from hierarchical and network databases to relational databases. As computer technology moves into nontraditional applications such as CAD/CAM, knowledge-based systems, multimedia, and Internet systems, many feel the limitations of relational databases in these data-intensive application systems. Therefore, some nontraditional data models for databases, such as the entity-relationship (ER) data model (Chen, 1976), the object-oriented data model, and the logic data model, being the tool of modeling databases, have been proposed.

One of the semantic needs not adequately addressed by traditional models is that of uncertainty. Traditional models assume the database model to be a correct reflection of the world being captured and assume that the data stored is known, accurate, and complete. It is rarely the case in real life that all or most of these assumptions are met. Different models have been proposed to handle different categories of data quality (or lack thereof). Five basic kinds of imperfection have been identified: inconsistency, imprecision, vagueness, uncertainty, and ambiguity (Bosc & Prade, 1993). Inconsistency is a kind of semantic conflict when some aspect of the real world is irreconcilably represented more than once in a database or in several different databases. Inconsistency has traditionally been applied to data. In the context of multidatabases, where multiple sources are integrated, attention was given to inconsistency at the modeling level. Imprecision and vagueness are two closely related qualities. They both relate to the context in which the value attributed to an attribute (or the interpretation assigned to a concept) is known to come from a given interval (or set of values) but we do not know exactly which one to choose at present. In general, vague information is represented by linguistic values. Uncertainty refers to those situations in which we can apportion some, but not all, of our belief to the fact that an attribute took a given value or a group of values. The random uncertainty, described using probability theory, is not considered in this chapter. Finally, ambiguity means that some elements of the model lack complete semantics, leading to several possible interpretations. Generally, several different kinds of imperfection coexist with respect to the same piece of information. A large number of models have been proposed to handle uncertainty and vagueness. Most of these models are based on the same paradigms. Vagueness and uncertainty are generally modeled with fuzzy sets and possibility theory (Zadeh, 1965, 1978). Many of the existing approaches dealing with imprecision and uncertainty are based on the theory of fuzzy sets. Fuzzy information has been extensively investigated in the context of the relational model (Buckles & Petry,

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