



Chapter XV

Modeling Fuzzy Information in the IF_2O and Relational Data Models

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ABSTRACT

Computer applications in non-traditional areas have put requirements on conceptual data modeling. Some conceptual data models, being the tool of design databases, have been 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 and the design of databases with imprecision and uncertainty. In this chapter, a different level of fuzziness based on fuzzy set and possibility distribution theory will be introduced into the IFO data model and the corresponding graphical representations will be given. The IFO data model is then extended to a fuzzy IFO data model, denoted IF_2O . In particular, we provide the approach to mapping an IF_2O model to a fuzzy relational database schema.

INTRODUCTION

A major goal for database research has been the incorporation of additional semantics into data models. Databases have gone through the development from hierarchical and network databases to relational databases. As computer technologies

move into non-transaction processing such as CAD/CAM, knowledge-based systems, multimedia and Internet systems, many feel the limitation of a relational database in these data-intensive applications. So some non-traditional data models for databases—such as conceptual data models (e.g., entity relationships/enhanced entity relationships [ER/EER]) (Chen, 1976), Unified Modeling Language (UML) (Siau & Cao, 2001), and IFO (Abiteboul & Hull, 1987)), object-oriented data models, and logic data models—have been proposed. Conceptual data models can capture and represent rich and complex semantics at a high abstract level (Fong, Karlapalem, Li, & Kwan, 1999; Halpin, 2002; Shoval & Frumermann, 1994); therefore, various conceptual data models have been used for conceptual design of databases. For example, the relational databases were designed by first developing a high-level conceptual data model, the ER model, and then the developed conceptual model was mapped to an actual implementation (Teorey, Yang., & Fry, 1986). As to the IFO model, it was extended into a formal object model IFO₂, and then the IFO₂ model was mapped into object-oriented databases by Poncelet, Teisseire, Cicchetti, and Lakhal (1993).

However, information is often imperfect in real-world applications. Therefore, different kinds of imperfect information have been extensively introduced into databases (Yazici & George, 1998). There have been some attempts to classify various possible kinds of imperfect information, although there are no unified points of view and definitions. But inconsistency, imprecision, vagueness, uncertainty, and ambiguity are viewed as the basic kinds of imperfect information in database systems (Bosc & Prade, 1993). Rather than giving the definitions of this imperfect information, we explain its meanings in the following:

- Inconsistency is a kind of semantic conflict, meaning the same aspect of the real world is irreconcilably represented more than once in a database or in several different databases. For example, the age of George is stored as 34 and 37 simultaneously. Information inconsistency usually comes from information integration.
- Intuitively, the imprecision and vagueness are relevant to the content of an attribute value, and it means that a choice must be made from a given range (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. For example, the age of Michael is a set { 18, 19, 20, 21 }, a piece of imprecise information, and the age of John is a linguistic “old,” a piece of vague information.
- The uncertainty is related to the degree of truth of its attribute value, and it means that we can apportion some but not all of our belief to a given value or a group of values. For example, the possibility that the age of Chris is 35 right now should be 98%. The random uncertainty, described using probability theory, is not considered in this chapter.
- The ambiguity means that some elements of the model lack complete semantics leading to several possible interpretations.

Generally, several different kinds of imperfection can co-exist with respect to the same piece of information. For example, the age of Michael is a set { 18, 19, 20, 21 } and their possibilities are 70%, 95%, 98%, and 85%, respectively. Imprecision, uncertainty, and vagueness are three major types of imperfect information and can be modeled with

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