CONCEPTUAL MODELING IN FUZZY OBJECT-ORIENTED DATABASES USING UNIFIED MODELING LANGUAGE

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Abstract—In real applications, information is often imprecise and vague. Exact information has become an essential part of modern database applications for making next generation information systems more human-friendly. Fuzzy techniques have been widely used to represent such vague information in various database models and theories. Because of the efficiency of object-oriented databases in handling complex objects, this database model is extensively used in representing and manipulating fuzzy data. However, there is less research done in the area modeling of fuzzy object-oriented database. In this paper, a conceptual model has been proposed for fuzzy object-oriented databases using unified modeling language.

Keywords: object-oriented database, fuzzy object-oriented database, unified modeling language

1. INTRODUCTION

A major goal for database research has been the cooperation of additional semantics into the data model. In real-world applications, information is often vague and imprecise[1]. Therefore, different kinds of imprecise information have been extensively introduced into relational databases. However, traditional relational database model in its enhanced form of imprecision and ambiguity[6] does not satisfy the need of modeling complex objects with imprecision and ambiguity. So many researchers have been concentrated on the development of object-oriented database models to deal with the complex objects and fuzzy data together. Conceptual modeling is one of the important phases in designing any database model. For designing the conceptual model of object-oriented database, unified modeling language (UML) has been extensively used because of its efficiency in specifying complex objects[2]. But still there is less research accomplished in the area of conceptual modeling of fuzzy object-oriented databases using UML. In this paper, a generic conceptual model has been proposed for fuzzy object-oriented database which uses class diagram feature of UML, so that fuzzy objects can be modeled in the most efficient manner. In section 2, the object-oriented database modeling has been described with the help of UML. In section 3, we have proposed have a new way of conceptual modeling of fuzzy Object-Oriented databases. Section 4 presents the conclusion of the proposed work.

2. OBJECT-ORIENTED DATABASE MODELING

In this section, we have discussed the basic concepts and techniques involved in OO modeling using UML[3,4], which includes notations, objects and classes, encapsulation of attributes and operations, association, generalization and aggregation relationships, cardinalities and other types of constraints, polymorphism ad inheritance.

• Notations

• Objects and classes

A class diagram shows the static structure of an object oriented model: the object class, their internal structure and the relationships in which they participate [7].
In the above figure 1, we can say that a class provides a template or schema for its instances. An object diagram also known as instance diagram, is a graph of instances that are compatible with a given class diagram. In object diagram, there are only two rectangular boxes. The name of object and its class are underlined and shown in top box. The objects attributes and their values are shown in second compartment. Figure 2 shows an object diagram with the attribute values.

### Association

An association is named relationship between or among instances of object classes [7].

The figure 3 shows binary association between the student and faculty, between course and course offerings etc. the diagram shows that a student may have an advisor while a faculty member can be advisor to up to maximum of 10 students. Also while a course may have multiple offerings, a given course offering is scheduled for exactly one course. This diagram also shows that faculty member plays the role of an instructor as well as that of advisor, while the advisor role identifies the faculty object. We could have named the association as say advises, but in this case the role names are sufficiently meaningful to convey the semantics of the relationship.

### Generalization

In generalization [7,8], a set of object class is changed into a more general class. We abstract not only the common attributes and relationships but also the common operation as well. In figure 4, a generalization path is depicted by a solid line from the subclass to the superclass with a hollow triangle at the end of and pointing towards the superclass.

### Aggregation

An aggregation expresses a part of relationship between a component object and aggregate object [7,8]. It is a stronger form of association relationship and is represented with a hollow diamond at the aggregate end.
2. CONCEPTUAL MODELING OF FUZZY OBJECT ORIENTED DATABASES

- Fuzzy set and possibility distribution

According to Zadeh[5], fuzzy data is defined as follows, suppose U be a universe of discourse then a fuzzy value on U is defined by a fuzzy set F in U, a membership function \( \mu_i : U \rightarrow [0,1] \) is defined for the fuzzy set F, where \( \mu_i(u) \) for each \( u \in U \). Therefore fuzzy set \( F = \{ \mu_i(u)/u_i, \mu(u_2)/u_2, \ldots \} \) where U is an infinite set then fuzzy set F can be represented by:

\[
F = \int_{u \in U} \mu^f(u)/u
\]

Where the membership function \( \mu_f(u) \) in the above expression is a measure of the possibility that a variable X has the value u, where X takes value in U, a fuzzy value is described by a possibility distribution \( \pi_X \),

\[
\pi_X = \{ \pi_X(u_1)/u_1, \pi_X(u_2)/u_2, \ldots \}
\]

Where \( \pi_X(u_i), u_i \in U \) denotes the possibility that \( u_i \) is true. Let \( \pi_X \) and F be the possibility distribution representation and the fuzzy set representation for a fuzzy value respectively. For Example, fuzzy set say \((0.6/21,0.7/22,0.95/23,0.85/24)\), for the age of Ram is more informative because imprecise information (age may be 21,22,23, 24) and we don’t know which one is true and uncertainty the degree of truth of all possible age values are respectively 0.6,0.7,0.95,0.85) simultaneously.

- Fuzzy object and classes

The objects have the properties of being attributes objects of its own or relationship also known as association between object and one or more other objects. Due to the lack of information an object is fuzzy. More general, objects which have atleast one attribute whose value is a fuzzy set are fuzzy objects. While a class can be considered from two different views viz, firstly as an extension class, where the class is defined as the collection of the objects and secondly as an intentional class where the class is defined as a set of attributes and their acceptable values in this case concept of inheritance is introduced.

- A class may be fuzzy because of he following reasons. Firstly some objects are fuzzy,which have similar properties. These object belong to the class with the membership degree of \([0,1]\). Secondly, when a class is intentionally defined. The domain of an attribute may be fuzzy and a fuzzy class is created. For example, a class Old Syllabus is a set of fuzzy values such as long, very long and about 30 year. Thirdly the sub class produced by a fuzzy class of specialization and the super class produced by some classes (in which at least one class is fuzzy) by means of generalization is also fuzzy. The main difference between fuzzy classes and crisp classes is that the boundaries of fuzzy class are imprecise which causes the imprecision of the value in the attribute domain in fuzzy OODB. Hence we can say that the classes are fuzzy because
the imprecision of the value in the attribute domain in fuzzy OODB. Hence we can say that the classes are fuzzy because their attributes domain is fuzzy. In this paper we have introduced a UML notation for fuzzy objects and fuzzy classes by adding membership functions and a dotted rectangle box.

Figure 6. UML fuzzy class diagram with two classes

In the figure 6, membership function is attached to the student and course which denotes the fuzzy classes. Here the attribute year in the student class is fuzzy because of set of fuzzy values {first, second, third, fourth}. In the same way, attribute credit_hrs of course class is also a fuzzy attribute. Thus we can say that a fuzzy class provides a templates or schema for its instances.

Unlike fuzzy class diagram, in fuzzy object diagram there are only two rectangular boxes with dotted lines. The name of object and its class is underlined and shown in top box and a object attribute and their fuzzy values are shown in second compartment as shown in figure 7.

Figure 7. Fuzzy object diagram with two instances

A function or a service that is provided by all instances of a fuzzy class is called fuzzy operation. The fuzzy operation thus provides an external interface of a fuzzy class. The interface presents outside view of fuzzy class without showing its internal structure or how its fuzzy operation are implemented. This technique of hiding the internal implementation detail of a fuzzy object from its external view is known as encapsulation or information hiding.

- **Association**

  An association is a named relationship between or among instances of fuzzy classes. It can be of unary, binary and ternary nature. We have shown the association relation of degree two (binary) among instances of fuzzy classes in figure 8. The binary relationship could be any of the following types.

  - **Generalization**

    On generalizing a set of fuzzy classes into a more general fuzzy class we abstract not only the common attribute (i.e. may be fuzzy) and relationship, but the common operation as well the operation also may be fuzzy. For example, consider a fuzzy class employee \( E \). Here \( E \) represents possibility of fuzzy membership for employee and there can be three type of employee i.e. hourly employee (HE), salaried employee (SE) and consultant (S). And HE, SE and S have the same meaning like \( E \). The feature that will be shared by all employee is emp_name, emp_number, address, age, date hired and print_label are stored in fuzzy employee superclass. Following depicts the generalization.

  - **Aggregation**

    As in simple UML theory aggregation shows a part-of relationship between a component of fuzzy object an aggregate object and it is not necessary for an object to be fuzzy.

Figure 8. Association of fuzzy classes

Figure 9. Example of fuzzy generalization, inheritance and constraints
In the figure 10, aggregation and composition of the class diagram of the university is shown. The aggregation constructor represents the aggregation abstraction of semantics model defined by the Cartesian product and this constructor connects a subtype representing a part of an object to the type representing the entire objects. The double hollow diamond represents a stronger form of aggregation known as composition. Composition is a part of object that belong to only one whole object and that starts and ends with the whole object.

4. CONCLUSION AND FUTURE SCOPE

In this paper we have discussed how the conceptual modeling of fuzzy Object-Oriented database will be done with the help of UML which deals with imprecise and inexact information.

Over the past thirty years many researchers have proposed fuzzy data modeling for relational database and object oriented database with the help of ER model,EER model,IFO model,Ex-IFO model and Ex-IFO2 model yet there is very little research done in modeling fuzziness at conceptual data level in fuzzy object-oriented database with the help of UML. So the future scope of our work will be to implementing this model to create a fuzzy database and retrieval of fuzzy information from these type of databases with the help of fuzzy object query languages(FOQL).

REFERENCE