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Research Article

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

Shivam Singh[1], Kavita Agarwal[1], Jameel Ahmad[1] and *Dharmendra Pal[2]

[1]Department of Computer Science, Integral University, Lucknow, India
[2]Department of Physics, BBD National Institute of Technology & Management, Lucknow, India
**Author for Correspondence*

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 object, 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*

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 (Parsons, 1996). 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 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 (Oscar *et al.*, 1997).

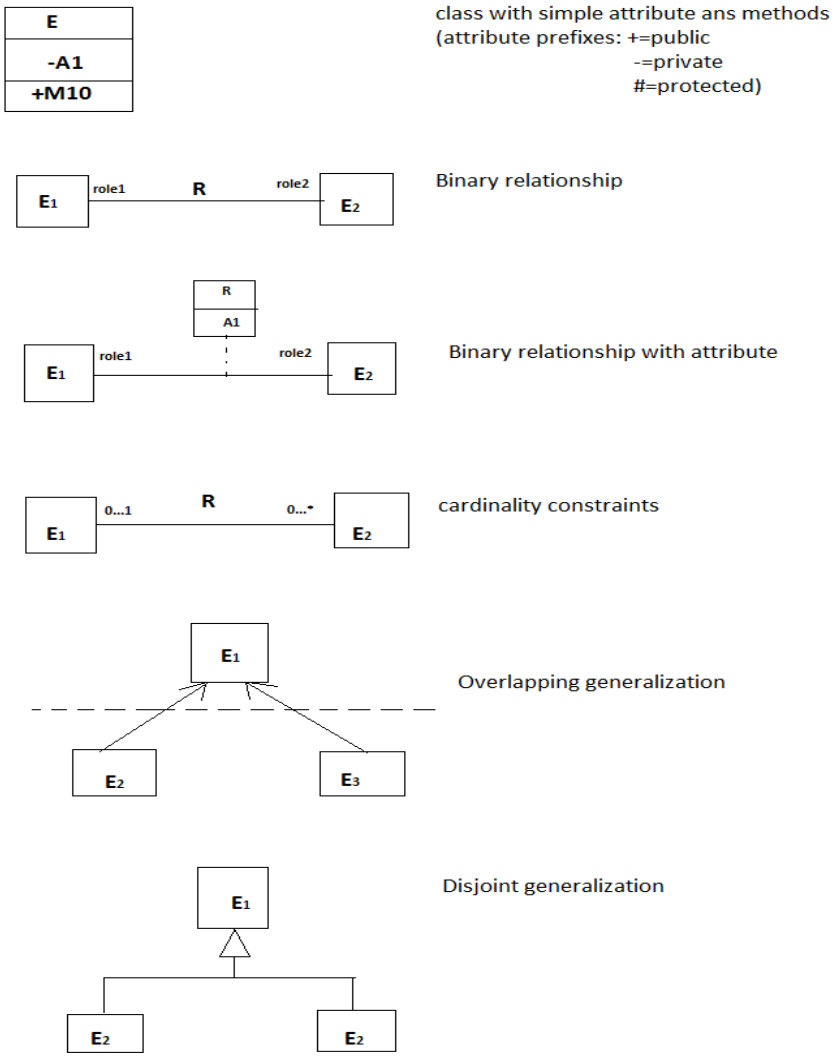
But still there is less research accomplished in the area of conceptual modeling of fuzzy object-oriented databases using UML.

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.

Object-Oriented Database Modeling

In this section we have discussed the basic concepts and techniques involved in OO modeling using UML (Ma and Yan, 2010; Ma *et al.*, 2004), 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 (Jeffery *et al.*).

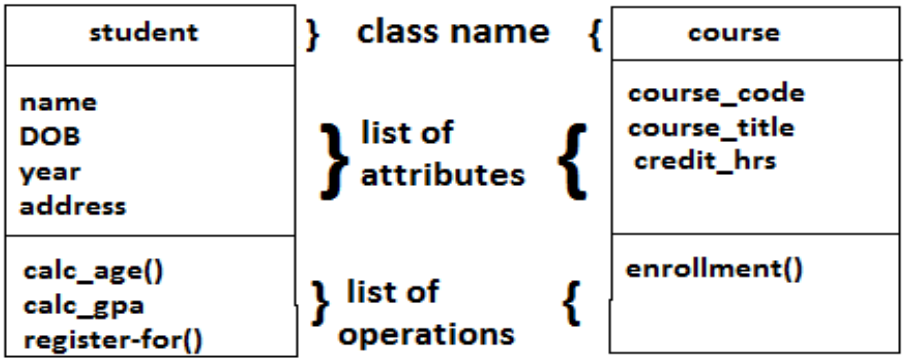


Figure 1: UML class diagram showing two classes

In the above figure1, 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 objet and its class are underlined and shown in top box. The objects attributes and their values are shown in second compartment. Figure 2 shows a objet diagram with the attribute values.

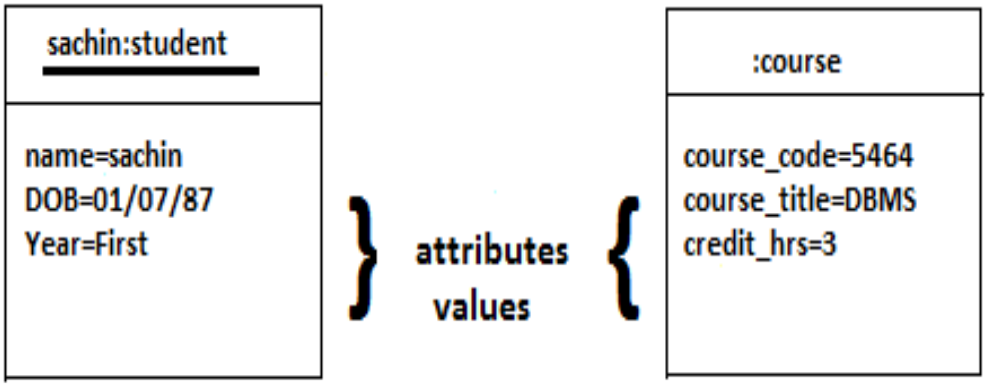


Figure 2: Object diagram

- ***Association***

An association is named relationship between or among instances of object classes (Jeffery *et al.*).

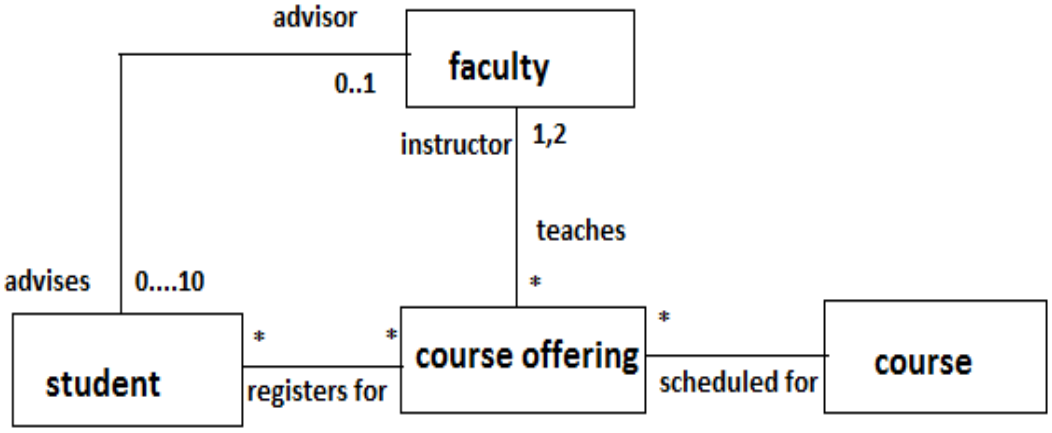


Figure 3: Binary association in university database

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 upto 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 (Jeffery *et al.;* Yazici and Cinar, 1998), 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.

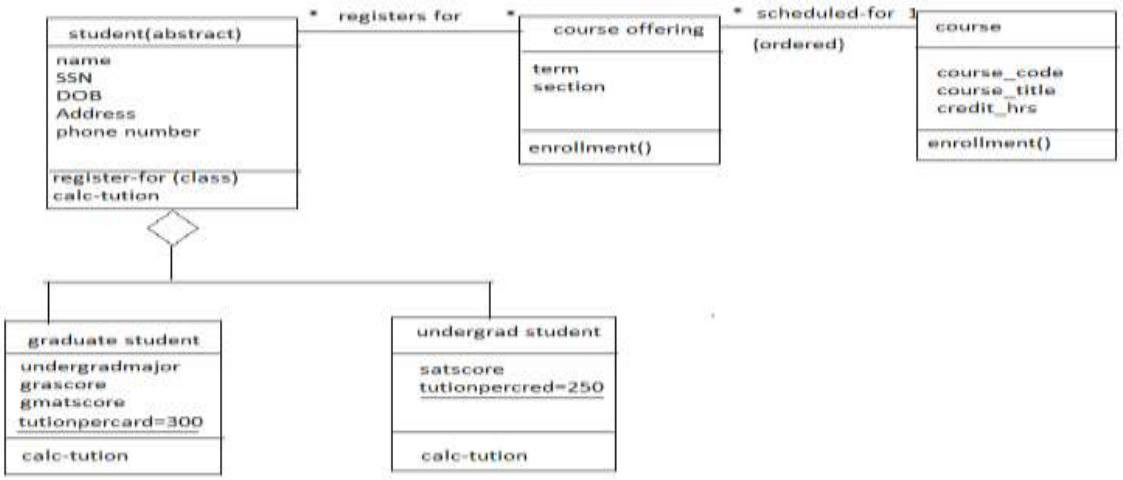


Figure 4: Generalization, aggregation, inheritance and polymorphism

- ***Aggregation***

An aggregation expresses a part of relationship between a component object and aggregate object (Jeffery *et al.;* Yazici and Cinar, 1998). It is stronger form of association relationship and is represented with a hollow diamond at the aggregate end.

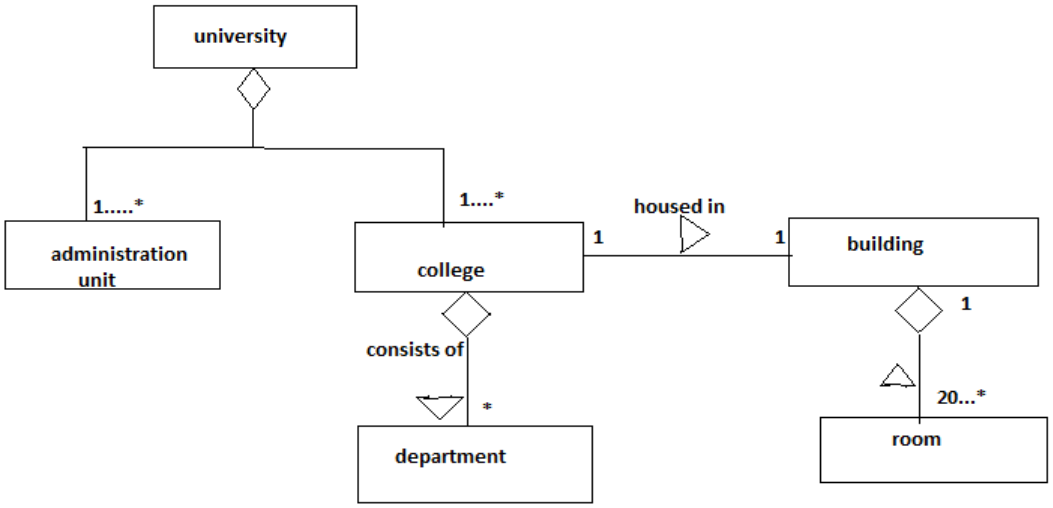


Figure 5: Aggregation and composition

Conceptual Modeling of Fuzzy Object Oriented Databases

- *Fuzzy Set and Possibility Distribution*

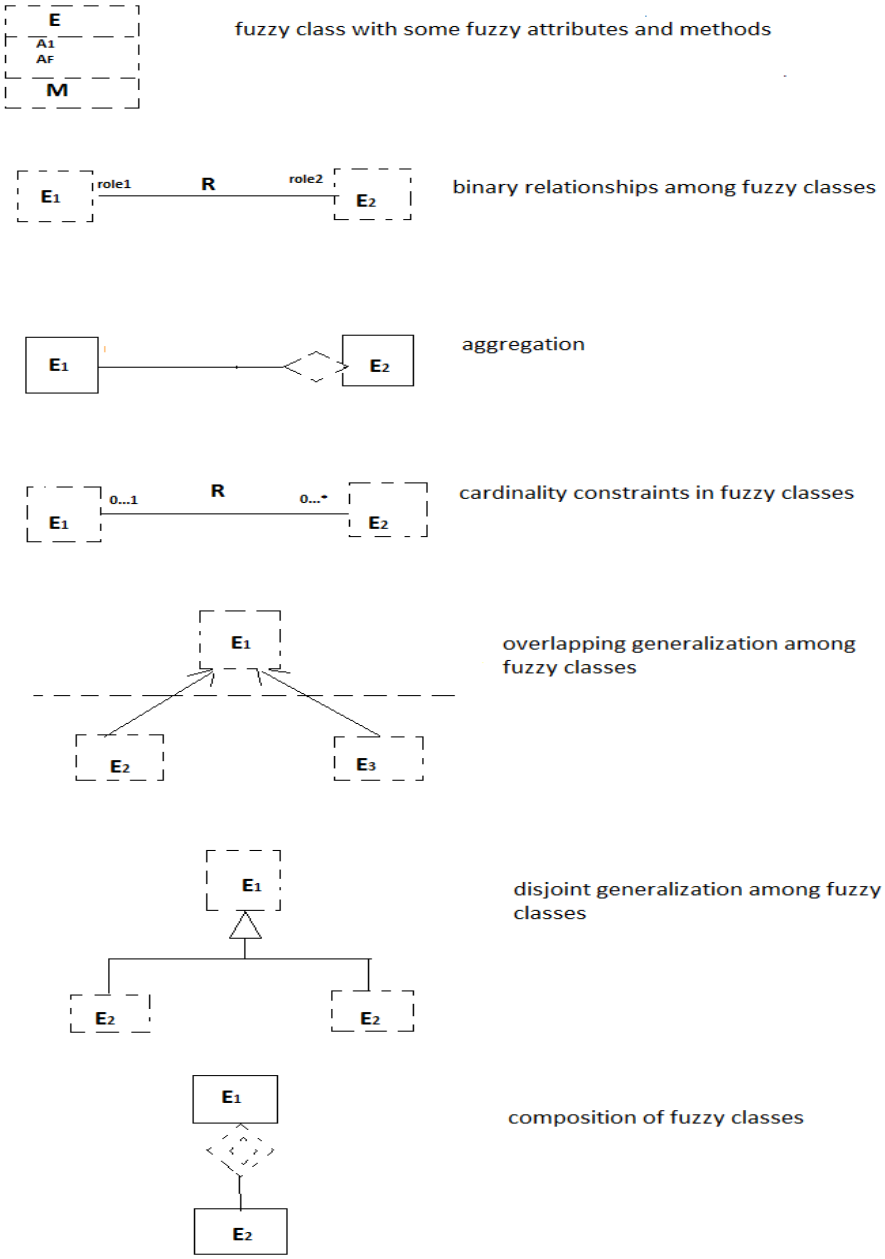
According to Zadeh[5], fuzzy data is defined as follows, suppose U be a universe of discourse then a fuzzy value on U is defined by a fuzzy set F in U. a membership function μ_f: U-> [0,1] is defined for the fuzzy set F, where $\mu_f(u)$ for each u€U. Therefore fuzzy set F= {$\mu(u_1)/u_1$, $\mu(u_2)/u_2$,……..., $\mu(u_n)/u_n$} where U is a infinite set then fuzzy set F can be represented by:

$$F=\int_{u\epsilon U} \mu f(u)/u$$

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 π_X.

π_X= { $\pi_X(u_1)/u_1$, $\pi_X(u_2)/u_2$…….. $\pi_X(u_n)/u_n$}
Where $\pi_X(u_i)$, u_i€U denotes the possibility that u_i is true. Let π_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.

- *UML Notation used to draw fuzzy Class*



- *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 at least 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 their attributes domain is fuzzy. In this paper we have introduces 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 an 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.

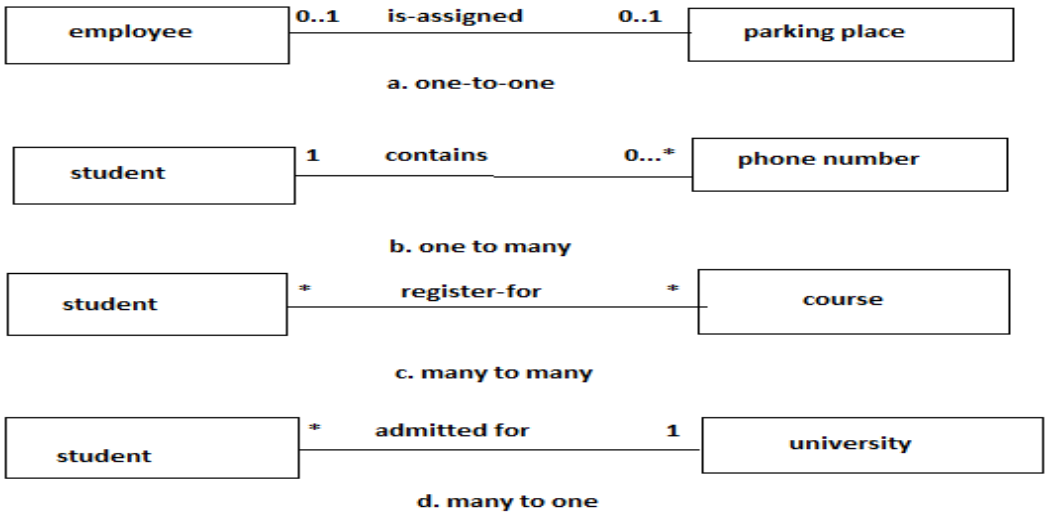


Figure 8: Association of fuzzy classes

- *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 $E_{f.}$. Here E_f 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_F, SE_F and S_f have the same meaning like $E_{f.}$. 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.

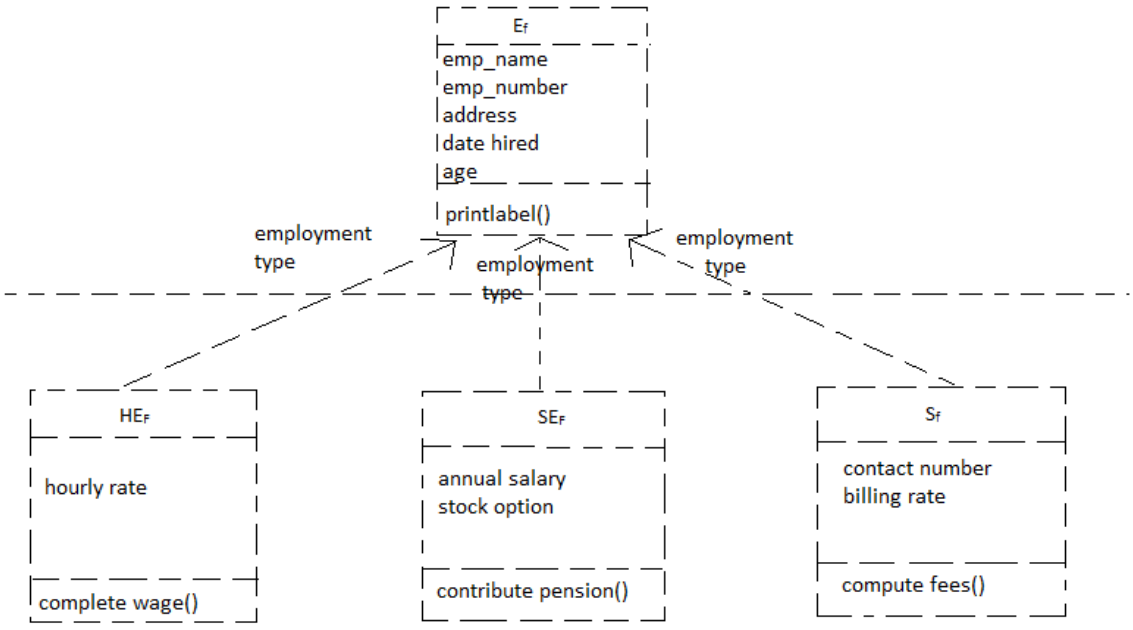


Figure 9: Example of fuzzy generalization, inheritance and constraints

Here in the figure 9, attribute will be inherited from the superclass that attribute may be of the fuzzy like age= {young, middle, old}. Generalization and inheritance are transitive across any number of levels of superclasss and subclass hierarchy.

- *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.

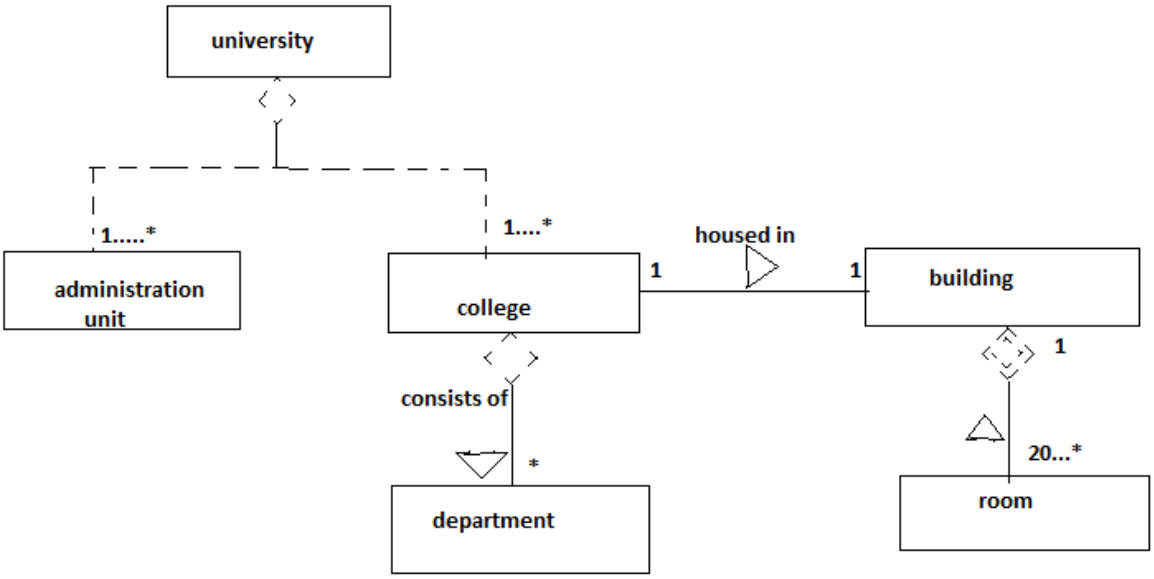


Figure 10: Aggregation and composition class diagram of university

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.

CONCLUSION

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 retrival of fuzzy information from these type of databases with the help of fuzzy object query languages (FOQL).

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