Knowledge based Integrated Information System Design using Object Oriented Methodology

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Integration of various information systems has set a unique irreversible trend in present information system design. The Information system designer integrates various environments, products to develop applications on multiple platform so as to give a common look and representation of abstracts opaque from the users. Object oriented database allow structuring and referential sharing of objects through the support of object identity and inheritance. "Object orientation system construction techniques" go beyond the technical issues of administrating structure providing, a tool to communicate with customizing application and to capture their expectations for the final product. This paper describes a generalized methodology for representing structural knowledge implicit to a database in a knowledge base, which is use to form an integrated knowledge base system. The logical modeling is done by using structured knowledge engineering and the physical model development is guided by SOM (Structured Object Model). The design steps are based on Booch's [6,10,13] Object Oriented Design methodology. Visual dBASE used as an application tool to realize the concept.

Introduction

Integration of database aimed to achieve two things referential sharing, where multiple applications, products or objects share a common subject and concurrent sharing of objects. Object oriented design(OOD)[5,6] achieve their modeling capability through the object oriented concepts of abstract data typing, inheritance and object identity. Inheritance and referencing[4] relationships are commonly used in knowledge representation. The object paradigm is well suited for design various type of complex information system. Most complex software and information system can be characterized by abstracts, that is objects and classes to capture resources, events and the tangibles of the application domain. The object oriented data base are extended to design Intelligent database by incorporating knowledge representation techniques. Where Artificial Intelligence used to implement inference rules to express integrity constraints, to capture domain expertise and to define more complex relationship. A knowledge based information system(KBIS) is designed with the integration of heterogeneous information resources because the knowledge are represented in various forms in different database.

Knowledge Based Information Processing

Object oriented knowledge base is designed to facilitate the knowledge based information processing(KBIP). A knowledge based system maps the input characteristics and behaviors of a system, problem, pattern or object through a knowledge base of expert information about the system. The input characteristics, behaviors represents process, events, symptoms, sizes and so on. The output represents solution, advice, decision, pattern match and so on. A knowledge base is created in particular domain. The knowledge stored is dynamic, that needing to be updated, corrected and soon. This is required because a new expert might contribute new information or it corrects it itself, or the system itself might generate new information. Hence Knowledge base information system requires mechanism to support the above features. In designing an information system KBIP provides several features that include:

- Application development using knowledge base, that leads to development of expert system,
- Designing user interface for non-programming users for effective access of information from large integrated network,
- Implementation of advance concurrence control mechanisms,
- Resolving differences in data semantics among various heterogeneous components,
- Intelligent control of database.

A system object space integrated with knowledge based processing to facilitate different requirements in application development. First the object oriented features like generality, flexibility and extensibility can be extended to knowledge based processing. Because sometimes system components uses heterogeneous

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knowledge representation techniques for betterment or the new techniques is found suitable for a specialized application. The object oriented technique integrating heterogeneous component becomes useful for integration of heterogeneous knowledge bases.

Second, integrating knowledge based processing into a system object space enables the behavior of objects to be derived from knowledge based processing. Hence it is irrelevant to outside objects whether an object behavior is derived from knowledge based processing or not. This facilitates a flexible way to integrate both conventional and knowledge based components whether in a same or different system.

Lastly integration of knowledge based processing into object space allows database management system components to provide object support for knowledge based applications.

Object Oriented Analysis and Design

The primary goal of object oriented analysis is the development of accurate and complete representation of problem domain. Numerous object oriented analysis methodology have emerged in recent past. Coad and Yourdon[10,13] object oriented analysis methodology is based upon the best concepts from information modeling, object oriented programming language and knowledge based systems. This results a five layer model[10] of the problem domain, where each layer is built on the previous layer.

Booch[6,10] defined four major steps that has to be performed during the course of Object oriented design(OOD) : (i) Identification of Classes and Objects, (ii) Identification of the semantics of classes, (iii) Identification of relationships between classes and objects, (iv) Implement classes and objects. The designing activities can be realized through [10, 13] tools like Class diagrams and Class templates, Module diagrams and templates, Object diagrams, Operation templates, Process diagrams, State transition Diagram and timing diagrams. The Booch's methodology guides the process of knowledge base development using *structure oriented model*.

Object Oriented Knowledge Representation

The goal of object oriented and knowledge representation [7,12] system is to model the real world as closely as possible. Knowledge representation is the process of formal representation of knowledge about a problem domain. Various methods[7] are available for knowledge representation and the method of knowledge representation technique depends directly on knowledge domain. A problem domain can be represented as a node-and-link[4,6,12] space where nodes are to represent their abstract concepts or specific objects, and the links can represents inheritance relationships, attributes and other complex or general relationships. The three fundamental concepts of object orientation are *abstract data typing, Inheritance and object identity.*

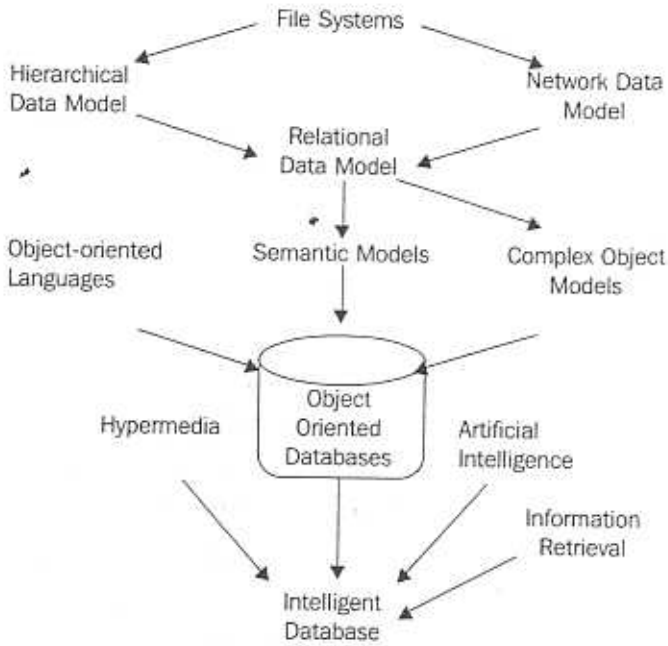

Fig. 1. Hierarchical representation of Intelligent Database

Abstract data types used to extend the notations of data type using *"hiding"* the implementation of user defined operation associated with a data type. Also all manipulations of the data type's instances are done through the operations associated with data type. In object oriented classes are used to define abstract data type. The instance variable capture the structure or state of an object which corresponds to slots in frame based knowledge representation or attributes(columns) in relational data base.

Where the inheritance is used to build new modules(classes) on the top of an existing hierarchy of modules. Also supports a mechanism for organizing information. It taxonomizes object into well defined inheritance hierarchies.

The object identity properties distinguishes each object from all other, with object with object identity, objects can contain or refer to other objects of the object space[5,6,12]. In modeling identities are assigned to the objects when they get created and identity continue to be associated with objects for its entire life time. The ability to refer the object directly and to avoid the problem of dangling reference in programming languages and data base with other advantages discussed above is best suitable for knowledge representation. Figure 1 shows how object oriented database guides the development of knowledge base using artificial intelligence techniques and inference mechanism.

Structured Object Model Development

The structured object Model(SOM)[8] is an object oriented model developed for database and knowledge base design. SOM represents data semantics using object attributes and two type of relationship aspects and specialization. The design process using SOM can be applicable to *logical* as well as *physical*

design. In SOM tangible object type with multiple instances(such as projects, employees and equipment's) are defined as classes with each instance representing a separate objects. The objects are described by their attributes using SOM, which is of two types as *identifiers* and *descriptors*. Identifier is used uniquely to identify an object instance, and a descriptor describes the state or properties of the instance. In design process a SOM diagram is constructed by decomposition and specialization. Decomposition represents object components and specialization represents an object classification. An object is decomposed to sub-objects by developing an aspect relationship. A specialization relationship indicates that a parent object can be specialized in only one of its sub objects.

Database design using Structured Object Model (SOM)

In the process of developing a Knowledge based information system(KBIS)[1,2] first the logical and physical database schema are developed for the target system and then the design is used to identify object relationship that will differentiate knowledge subsets, search paths and inference patterns that are represented in a knowledge base.

The design procedure in SOM database development is guided by Booch's OOD procedure[13]. The procedure carried out in four steps :

s1 : Define the most general object and identify all relevant classes and attributes of a selected problem domain,

s2 : Define relationship between classes,

s3 : Verification of completeness of relationships,

s4 : Simplification of SOM diagram and copy each object structure to a relation.

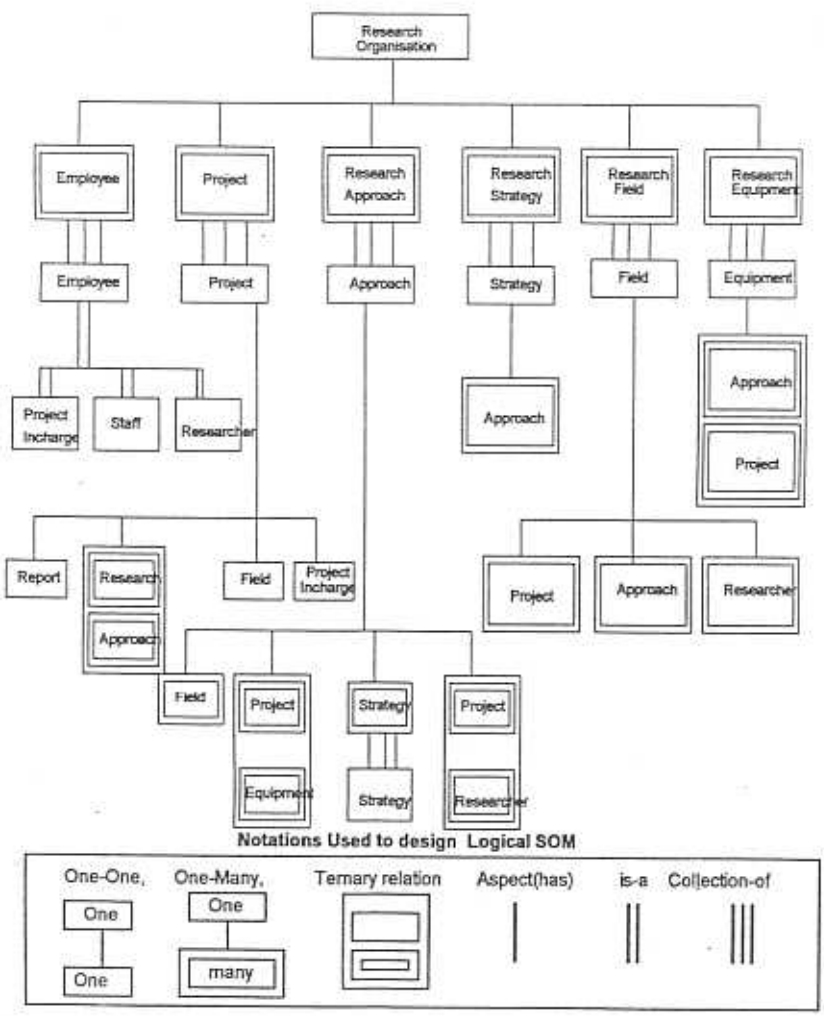

Fig. 2. Logical Structured object model

A Medicine and Drugs Research Institute is taken as prototype system to design a knowledge based information system. The development process is guided by system engineering[13]. The system engineering begins by taking a global view . First it analyzes the organizational domain to establish the requirements. In our example it involves 7 distinguishable objects as *EMPLOYEE, PROJECT, REPORT, RESEARCH-APPROACH, RESEARCH-STRATEGY, RESEARCH-FIELD,* and *RESEARCH-EQUIPMENT*. The logical SOM as shown in Figure 2 is design following the procedure describe in preceding section. Then Commonly existing four different type of relationships between various objects are *one-to-one , one-to-many, many-to-many* and *ternary* relationship rules are applied to logical SOM to transfer the logical SOM into physical SOM(Figure 3). The upper half of rectangle represents *class name* and lower half represents *attributes* . Attributes with upper case letter indicates *class identifier*. Duplicate occurrence of object outlined with doted line. The five out of seven objects of database development are translated directly into relations. They are known as simple objects which guides the creation of complex objects like *EMPLOYEE PROJECT-APPROACH, PROJECT-EQUIPMENT-APPROACH, PROJECT REPORT, APPROACH-PLAN* and APPROACH FIELD. The schema of the above object are used to describe the database.

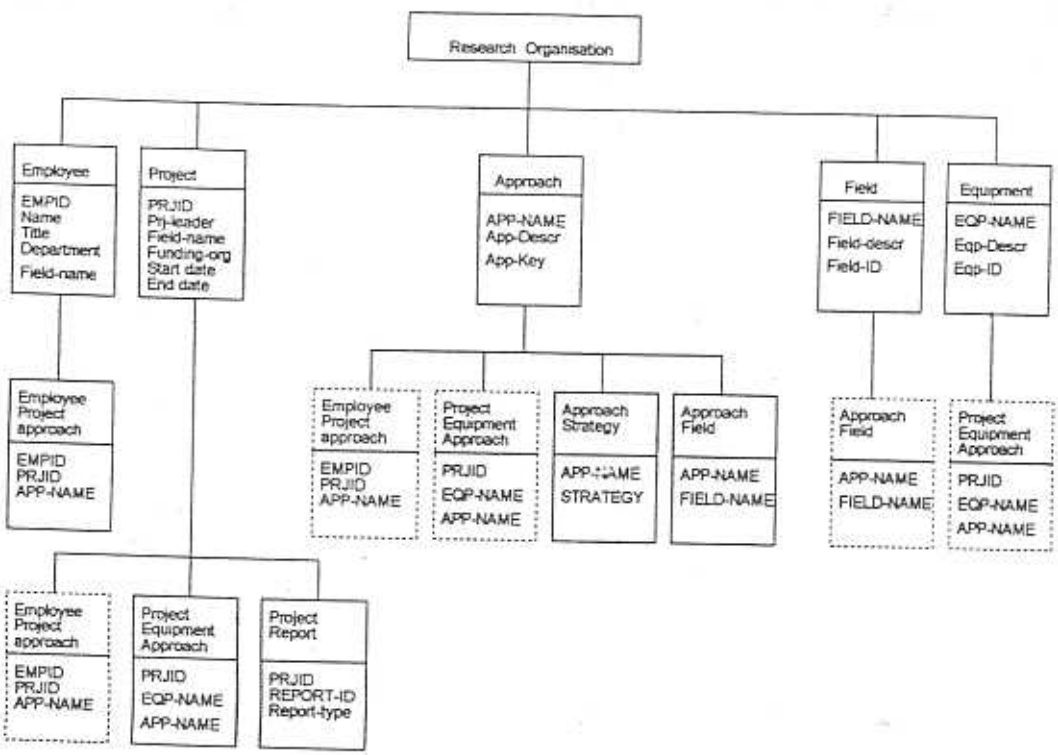

Fig. 3. Physical Structured Object Model

Knowledge base development in general requires two different type of knowledge, *extensional* and *intensional* . In the context of database development the extensional knowledge is consists of instantiations of organizational objects and its activities. These knowledge are stored in the database. The intensional (semantic) knowledge describes the structure of the database to be designed . This further can be partitioned into *(i)general semantic knowledge;* which is analogous in to conceptual schema or global view of the database and (ii) *task specific knowledge;* which is analogous users view of database or sub-schema.

General semantic knowledge (GSK) includes description of organizational objects and associations among those objects. Here SOM diagram is the representation of GSK . GSK is to be used as a security guard and policy enforcer of the organizational data base. Before GSK representation, the design of task-specification semantic knowledge design to be completed so that it can guide GSK.

Next to transform of SOM entities to Nexpert[6] class. Nexpert connects class/object structures and rules by their common data,

classes or hypothesis and thus forms object and rule networks . The process displayed in figure 4. Nexpert supports rules associated methods. Hence the rules can be structured in to *rule-net* . Rule-net is network of rules supporting forward, backward or combined of forward and backward chaining . A rule net box for a single class (Figure 5) consists of "IF" clause in left hand side(LHS) and hypothesis in right hand side(RHS), that includes hypothesis-name and action clauses. When LHS is true, the hypothesis also becomes true and specified action executed. In class_diagram , "input" is an input item, a_ID is identifier property of A.

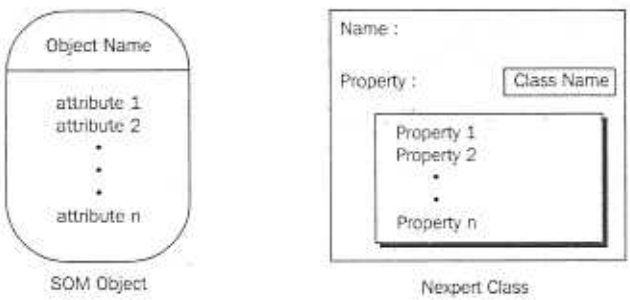

Fig. 4. SOM entity transformation to Nexpert Class

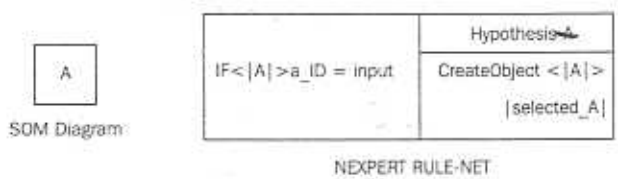

Fig. 5 . Representation of a single class Rule-net

A subclass is represented using figure 6, where flag is a Boolean property of class and select_A contains all property of class A and its sub-classes

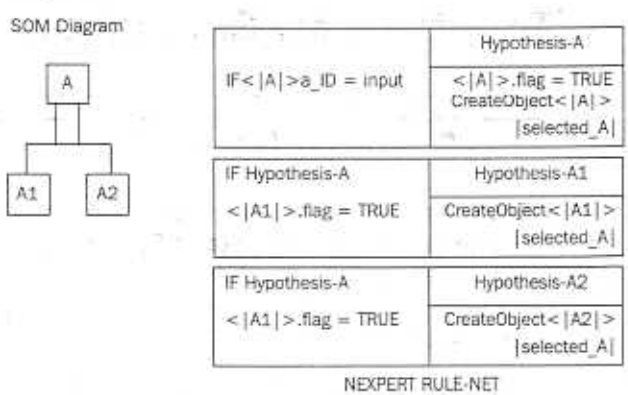

Fig. 6. Representation of a sub-class Rule-net

After the design of rule-net the data base is created using standard features of selected OOD and application programs to be designed for specific requirements. One can view the over all design process as a 3 step activity :

- s1: representation of database structure using OOD principle,
- s2: Collection of required objects from GSK and a SOM has to be constructed,
- s3: Development of application program(search strategy) based on SOM .

Data Base Integration and Implementation

The process of designing KBIS[9] requires (i) integration of various existing heterogeneous databases, (ii) Integration of conventional and non-conventional data type, (iii) Complete relational database-management functionality for the integration of data, (iv) Definition of object methods using varying existing application, (v) Run time combination of diverse processing components in response to a request, (vi) Support for arbitrary level and for advanced forms of inter-operability among components. To implement the above capabilities one needs a generalized object oriented DBMS.

We have selected Visual dBASE for system design. Visual dBASE featuring an object oriented programming language which allow the system designer to create sophisticated scaleable application using object and classes. Event driven application supported by Visual dBASE facilitates to develop application, where the user doesn't have to learn a complex hierarchy of menu choices. Rather, when choosing to enter an data/information the user finds the input screen similar to a familiar paper form. Event driven interface reflects the way people work in the real world, where a user can select an object and performs action on them. This provides a complete set of graphical interface objects and controls which enable us to create custom controls. Dynamic Data Exchange(DDE)[11] features of visual dBASE facilitates, one application in a DDE link-up is client and the other application is the server. The client queries data from the server, sends data to the server, or sends the server command to execute. The server plays a more passive role, it is invoked by the client, and it receives data, yields data or performs tasks as instructed by the client. The dBASE can be client or server or both simultaneously, that it can invoke or instruct any other application or invoked or instructed by other application. This facilitates the design of different knowledge base at client site in a client-server system. Visual dBASE also supports seamless access to a number of tables through Boroland Database Engine(BDE) with object linking and Embedding (OLE) permits to use external applications directly from a dBASE table or form.

Conclusion

Object oriented database can become the ideal knowledge representation mechanism of the information shared by multiple users, products and applications on different verity of platform. This paper discussed only the methodology for representing structural database knowledge in a knowledge base to an example application. But this concept can be extended to develop object

expert system shells. If one has to master information and survive in today's world of information glut and systemic complexity, one need to access and use information and develop intelligent database applications that provide more people with better access to needed information.

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