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Designing an Expert System to Diagnose & Treat Ear Illnesses

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Abstract:- An expert database system is an expert system which is developed using DBMS technology to manage facts and rules. Frame-based expert systems are widely using as the knowledge representation for such expert systems with large knowledge bases. Many systems have the ability to connect to external databases. Facts stored in databases can be loaded into expert system's knowledge base and inference is performed by the inference engine of the expert system. In many cases, such external facts are required several times for each inference. Thus, a lot of communication traffic takes place. This research work presents the design and implementation of a frame-based object-relational database system which has a tight coupling between the expert system and the external knowledge base. The external knowledge base also use frame as its knowledge representation. Moreover, it has its own inference engine so that inference can be perform on the knowledge base side and the results, are sent back to the expert system for further inference. In this research a medical consultation system is used as an illustrated example and an Oracle 10g object relational DBMS is used as the database platform.

Keywords: Frame-based Expert Systems, Object-Relational Database, DBMS Technology, Medical Consultation System

1. Introduction

Frames are widely used as the knowledge representation of large, complex expert systems [1]. However, most such expert systems shells have internal frame-based knowledge bases. They are internal in the sense that frames are loaded and stored in the main memory of the expert system during consultation sessions. The knowledge bases do not have the advanced data management facilities such as indexing, query optimization, concurrency control and recovery control which are common in modern database management systems (DBMS). During a consulting session, there are facts that are obtained from the user interactively and facts that are obtained from inferences. Inference rules in conventional expert systems are executed by the inference engine on the expert system's machine. It mainly uses facts obtained interactively from users. Facts from external databases are sometimes loaded into the knowledge base when required by the inference

process. In simple systems, relations that contain both relevant and irrelevant facts are loaded into the knowledge base. In more advanced systems only related facts are loaded. In both cases, there are no inferences on the external database (or knowledge base) side. Our approach is different. We propose an architecture that includes an inference engine on the external knowledge base side as well as one on the expert system shell side. This approach enables inferences to be performed on the external knowledge base side so that only the inference results are sent back to the expert system instead of sending facts several times during an inference process performed by the expert system's inference engine. Due to the similarity between the frame and the object relational concepts, a prototype system is implemented on an object relational database using Oracle 10g DBMS.

In continue of this paper, second section presents an overview about frames and explains their differences with objects. Third section shows the relationship between expert system and database. Forth section presents the proposed architecture and compare this architecture with other available architectures. Section fifth explains implementation steps and section sixth includes discussion about Medical Diagnosis Expert System. Finally section seventh summarize the paper and shows the conclusion.

2. Frames

Frame was introduced by Marvin Minsky in 1974 [2]. It is a knowledge representation that has both the data structure and inference capability. It is suitable for the representation of concepts and classifications. It is also suitable for the representation of a taxonomy hierarchy [3][4]. A frame comprises a frame name, slots or attributes of the frame and facets [5][6]. For clarification, frames can be classified into class frames and instance frames. Class frames are used to describe group of objects or class of objects and can also be organized into taxonomy. A class frame therefore has parent and children as common slots. Slots from a parent frame can be inherited to its children. Instance frames, on the other hand, describe particular object instances. They are the leaf node of the taxonomy and have no children [4][5][6][7][8]. Facets are used to control slot values and corresponding operations. It can be used to establish initial slot value, slot data type, possible value range and next activity to be performed. Validation rules, trigger operations and derivation rules are common facets as well. Frames are similar to objects in object programming and databases but the most important difference between them is the former lacks the encapsulation property. Objects are encapsulated but frames are not. Attributes of an object class cannot be seen from object users. They can only see method signatures. Objects without encapsulation which is well known under the name “object relational” are therefore a perfect match of the frame concept. This is the reason why an object relational DBMS is employed in this research project.

3. Coupling between expert system and databases

As mentioned earlier, the coupling between an expert system and a database system extends the capability of the former to have access to larger databases [9]. There are several systems that have the capability such as the Perk database [10], EcoCyc [9], PARKA-DB [11] and Sophia [12]. All of them employ relational databases to record facts. The Perk database connects to a database using OKBC operations [10] and refers to frames in the database by loading frames into the main memory for inferences. Its later versions employ object views and uses indexes to point to the required frames. EcoCyc system and PARKA-DB keep frames in relational database and load them into the main memory when required. Sophia also keeps frames in relational database and use SQL query for frames loading. All of them do not have the inference capability on the database side. Only tuples of relations are transfer to the expert systems. In the following section, we propose an architecture which employs an inference engine on the database side. Frames are kept in an object relational database. The expert system can request derived facts which can be obtained as a result from the inference that takes place on the database side. Since the database side has frames and the inference capability, we therefore call it an external knowledge base.

4. The System Architecture

Figure1 shows the architecture of the FORXDB (Frame-based Object Relational Expert Database system). The novel feature of this architecture is that it has an inference engine on the external knowledge base side (the server side). Frames are on both the server side and expert system (client) side. The client side frames are those that involve user interaction and fact acquisition. Inference on this side can lead to a reference to the facts on the external knowledge server that can be inferred from other server-side frames. The client expert system side comprises the user interfaces both for the expert and the user, the frame-based internal knowledge base, the knowledge base maintenance tool and the client-side inference engine. The external knowledge server comprises an inference engine, an object relational DBMS, the external frame-based knowledge base and other databases that belong to other information systems. These systems are the data sources of the external knowledge base.

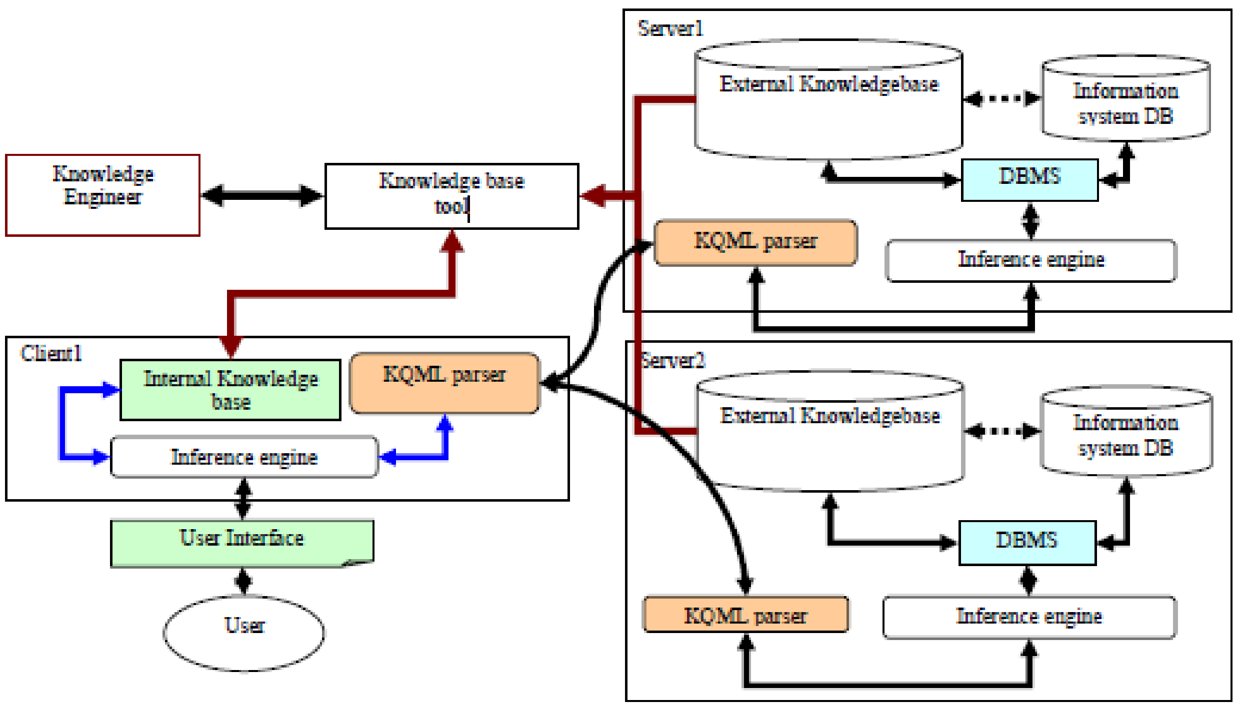

Figure 1: The FORXDB System Architecture

5. Implementation Issues

5.1. *The Meta Tables*

The FORXDB on frames is kept in system tables. Figure 2 shows an Object Role Model

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(ORM) [13] [14] diagram that describes frames. Corresponding meta tables with some sample data are shown in Figure 3.

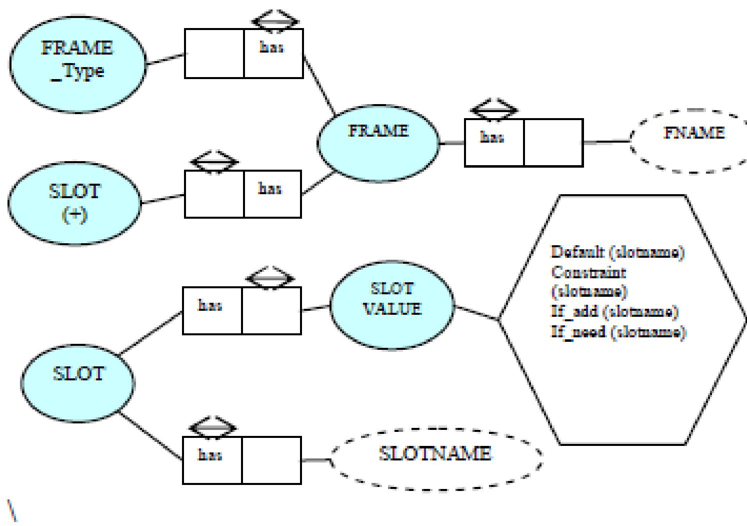

Figure 2a: A Frame sub schema Using NIAM

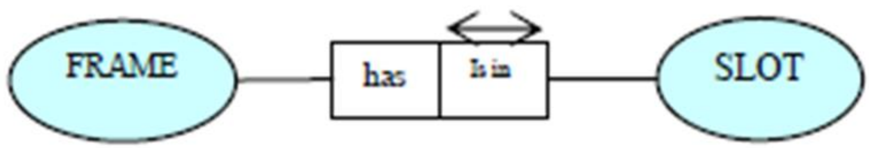

Figure 2b. A Frame main schema Using NIAM

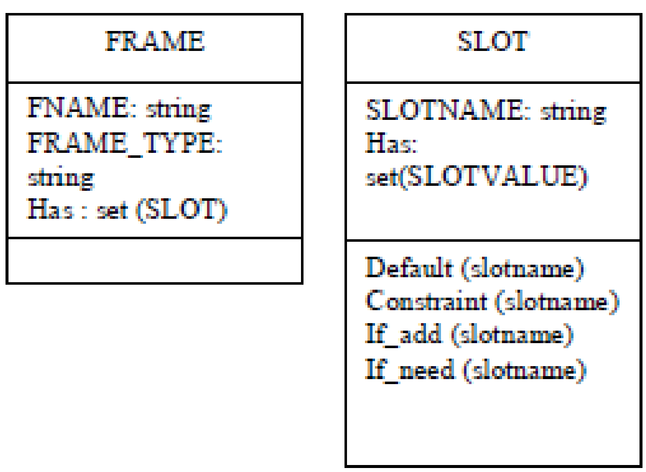

Figure 3: Frame Object Schema obtained from Figure.2

5.2. External Database Data Source

In this project, data from existing information systems are used as the data source to the FORXDB system. Inferences are performed on frames which refer to other frames until a fact is found in a database. Methods are employed in order to refer to facts on the data source without copying them permanently to the frames. Thus avoid data inconsistency when updates are made to the data source. In this project, Oracle 10g object-relational DBMS is used to manage the external knowledge base. Since Oracle 10g has a feature called db-link which allows an Oracle DBMS to refer to other Oracle databases and use SQL data manipulation statements directly on them. In the case that the external databases are not Oracle, a utility called OCA (Oracle Open Client Adapter) can be used to retrieve facts from them. In the implementation of the FORXDB system, only fact retrieval is required so we are well-equipped with data access tools. Facts which can be obtained from an external source are predefined by the expert. For example, patient records in hospital information systems are needed for a medical expert system consultation. If the required records are not available, then the expert system will ask the user interactively. Frames that interact with external databases are instance frames. Their corresponding class frames have attached procedures in the fact. The instance frames actually inherit these procedures from them.

5,3, Object Relational Database

An object relational database supports non-atomic attributes. A table needs not represent a relation in the traditional sense. Multi-valued attributes, composite attributes and simple attributes are allowed. User-defined data types (UDT) are also allowed. These UDT comprises other attributes and methods and are fully encapsulated. The concept of types and instances are clearly distinct. Unlike some simple relational database implementation that mixed the concepts of relational schema and relation in to a table, object relational allowed types (or row types) to be separately declared from table instances. Table 1 shows a sample table FRAME with a composite attribute SLOTNAME and a multi-valued attribute SLOTVALUE.

Table 1 . Frame Object-Relational Schema

FRAME			
FRAME NAME	FRAME TYPE	SLOTNAME	SLOTVALUE
			SLOTVALUE
		SLOTNAME	SLOTVALUE
			SLOTVALUE

The ... tog ... bel ... The ... nor ... wit ... use

```
CREATE OR REPLACE TYPE t_facets_row AS OBJECT ( ID N
SLOT_ID NUMBER(10),
NAME VARCHAR2(50),
SLOTVALUE VARCHAR2(50)
)
CREATE OR REPLACE TYPE t_facets_tab AS TABLE
OF t_facets_row
CREATE OR REPLACE TYPE t_slots_row AS OBJECT (
ID NUMBER(10),
FRAME_ID NUMBER(10),
SLOTNAME VARCHAR2(50),
FACETS t_facets_tab
)
CREATE OR REPLACE TYPE t_slots_tab AS TABLE OF
t_slots_row
CREATE OR REPLACE TYPE t_frame_row AS OBJECT
( ID NUMBER,
FRAMENAME VARCHAR2(50),
FRAMETYPE VARCHAR2(50),
SLOTS t_slots_tab
)
```

6. A Prototype Medical Diagnosis Expert System

Medical diagnosis is a process that requires skilled and qualified physicians. In remote areas where doctors are not available when required, other less qualified health care personals may have to do the job. A medical diagnosis expert system will be an invaluable tool in such situations. Patient's records, symptoms and illness history are essential information for the diagnosis process. It is clear that some information should be available on external databases (such as the patient's records) and others have to be obtained from patient's interviews. A frame-based expert system uses set of rules for inference. Rules are facets in slots. There is a trigger mechanism that checks activities on a slot. If add, if need, if change and if remove are typical facets which take action when slot value is manipulated. In the FORXDB system, forward chaining is employed. Since the

system has 2 inference engines, one on the client side and another one on the knowledge base (knowledge server) side, inference can be done on both sides. The client side first takes care of user interaction to obtain current information interactively while the server side takes care of the inference from recorded or historical information. In the medical diagnosis system, the client -side inference engine guides patient through relevant questions based on the given symptoms. Figure 4 shows an instance frame. Basic Questions which is created from a class frame. The user specifies the earache symptom and the corresponding slot value is set to true.

The If Change attached procedure of the slot will refer to the frame instance “symptoms to earache” which leads to further information on the patient. Finally, patient information frame instances are created. It will be submitted to the knowledge base system on the server side for further inference.

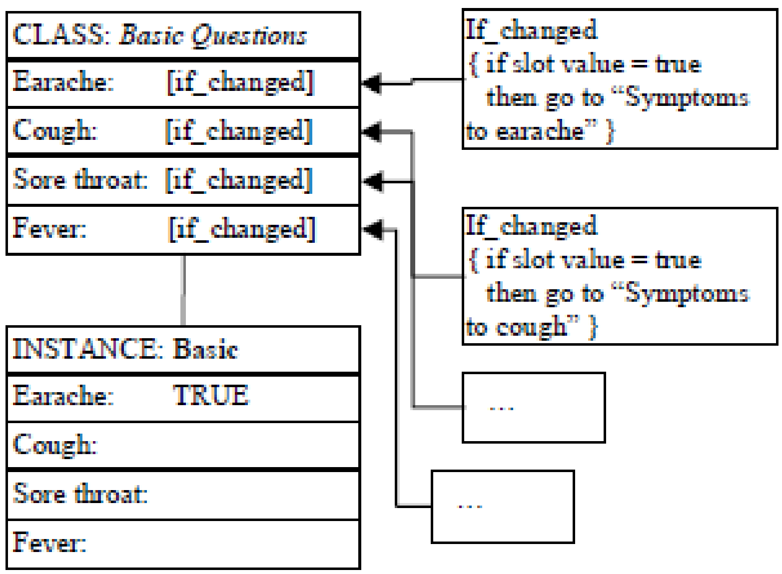

Figure 4: Sample Frames on the Client Side

There are two techniques that are employed for the server side inference. The first one is to keep the frame instances from the client side as server side frame instances. Methods on the slots will direct inference to the final goal. The second technique is to keep information from the client as parameters of store procedures which in turn, carry on the inference. This second approach is suitable for small amount of information is received from the client side. Figure 5 summarizes the inference activity in the frame system.

Frames on the client expert system side guide the patient’s interview process and send information obtained to the server whose frames access external databases and perform diagnosis. Appendix A shows server-side frames of ear-related problems and appendix B shows client-side frames of earache cases.

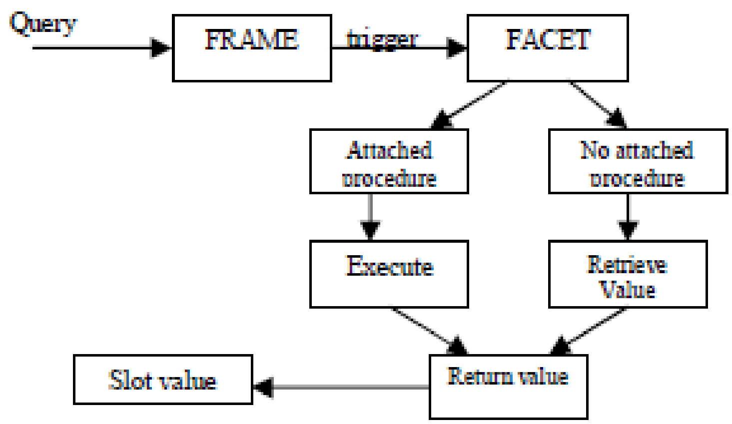

Figure 5: Frame inference mechanism

7. Conclusion

The paper presents a frame-based expert system architecture that has an inference engine on both the client consulting expert system and on the knowledge base. Inferences that are performed on the client side are mainly user's interviews and interactive fact gathering. Inferences on the knowledge base.

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