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Short Paper

A Design and Implementation of Museum Multimedia Information System

YIN-FU HUANG AND TIEN-YU HSU
Institute of Electronics and Information Engineering
National Yunlin University of Science and Technology
Yunlin, Taiwan 640, R.O.C.
E-mail: huangyf@el.yuntech.edu.tw

A museum multimedia information system is designed not only for entertainment, but also for education and research. Within the system, a huge number of intellectual assets is stored in a multitimedia database. Users can query the multimedia database and retrieve information matching the specified conditions. In this paper, we successfully apply the EER (Extended Entity-Relationship) model to describe the entire system. We also propose multiple retrieval functions including browsing and query, for various users to access the information in a flexible and efficient manner. Finally, a prototype system is developed based on WWW client/server systems and the object-relational DBMS UniSQL.

Keywords: multimedia databases, client/server, data model, conceptual design, WWW

1. INTRODUCTION

People all over the world are working with multimedia systems [1, 2] which provide many ways to present information. Through digital images, moving pictures, and beautiful melodies, people can communicate with each other in various ways [3, 4]. Most current multimedia systems are designed for a single user and the applications are developed on multimedia personal computers (MPC) using the basic software, hardware, and high-quality audio and video playback devices. In addition, some authoring tools can be used to integrate various types of media into a single document. However, multimedia systems for a multi-user environment are now in great demand. Since one of the features of multimedia information is the integration of a huge amount of complex structured data, the DBMS technology has been applied in multimedia servers.

Currently, there are three major types of DBMS's on the market, that is relational, object-oriented, and object-relational DBMS's. Several reasons why object-oriented technology rather than the relational technology is suitable for multimedia systems are as follows [5]. First, multimedia objects are complex in structure. However, videos, digitized voices, and images are not supported in a relational DBMS. Although Binary Large OBjects (BLOB's) can be described in some relational systems, they are not modeled and inter-

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preted sufficiently. Second, multimedia information systems require an extended data model to define new types and to add or delete new multimedia types dynamically [6]. Object-oriented systems meet this requirement much better than relational ones. Third, multimedia documents are complex structured objects, and the relationships among them, such as classification, specialization/generalization, and aggregation, should be modeled. For these reasons, an object-oriented DBMS is superior to a relational one.

In this paper, we design a museum multimedia information system to deliver knowledge of artifacts and collections to the public. In Section 2, we start with the architecture of a museum multimedia information system. In Section 3, we use the EER model for both system modeling and multimedia document modeling in the conceptual design phase. Moreover, we illustrate browsing, querying, and presentation procedures for the multimedia database in Section 4. Section 5 describes how the prototype system has been implemented. Finally, we draw a conclusion in Section 6.

2. THE MUSEUM MULTIMEDIA INFORMATION SYSTEM

In the National Museum of Natural Science (NMNS), the multimedia information system can be divided into four areas: Exhibition hall, Collection repository, Electronic library and Science classroom. Five design issues should be considered when the museum multimedia information system is developed:

- **Top-down design for a global view**
  To meet the requirements of research, education, and entertainment, we must try to integrate current traditional databases and new multimedia information into a complete hierarchy of museum multimedia databases. Here, a top-down design using the Extended Entity-Relationship (EER) model is adopted.
- **World wide access**
  The significant growth of the Internet has provided a good environment in which to share a variety of multimedia information. Especially through mature client/server network technology and popular browsing tools, e.g., Netscape, we can distribute our abundant intellectual information all over the world through the Internet.
- **Multiple retrieval criteria for various types of users**
  In order to access the database conveniently and efficiently, multiple retrieval interfaces, including browsing and querying by various forms of predicates, are supported.
- **Integration of diverse media in a single document**
  In order to reveal the diverse forms of information, we integrate text, image, audio, and video data in a multimedia document, and display them on the screen at the same time.
- **Contents of the information system**
  The contents of the information system must meet the requirements of query and presentation specifications for end-users.

As shown in Fig. 1, the museum multimedia information system is based on a client/server architecture, where clients can query multiple multimedia databases.

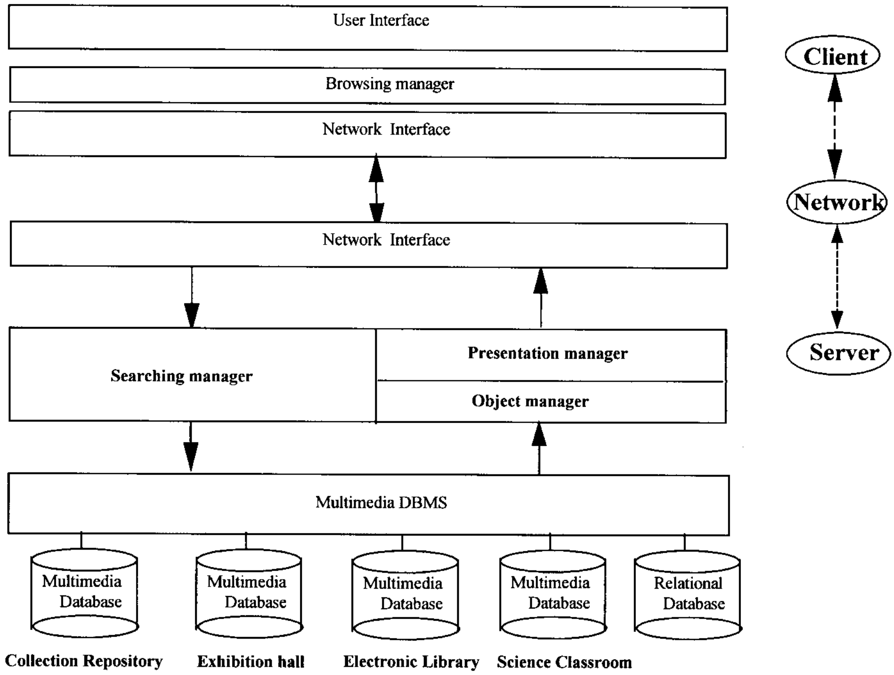

Fig. 1. Architecture of the museum multimedia information system.

For a client, a visual user interface was designed to provide flexible access to the integrated information in multimedia databases. Users can browse or query by means of predicates to retrieve the required information. At the server end, a searching manager is needed to receive the requests from clients and transform them into standard query commands for the DBMS to use to find the target information. Once the results are found, the object manager organizes the media objects according to the predefined structures, and delivers them to the presentation manager. Then, the presentation manager generates the display formats dynamically and, through the network, transmits them back to the client end for display [7].

3. CONCEPTUAL DESIGN FOR THE MULTIMEDIA DATABASE

3.1 Design Methodology

The database design can be divided into two major phases: conceptual design and implementation design. Conceptual design is the process of mapping a real world into a semantic model [8]. The activities include capturing all relevant information, specifying the inter-relationships among them, and defining the integrity constraints. Here, we use the EER model [9-11] for both system modeling and multimedia document modeling in the conceptual design.

3.2 System Conceptual Modeling

The major goal of conceptual modeling is to integrate different user views of an enterprise into one global and consistent model, in which entities and relationships are explicitly defined. Various queries, forms, and interfaces are derived based on the model, and data is retrieved from the corresponding database. The conceptual view defined here has nothing to do with multimedia issues. In Section 2, we introduced the architecture of the museum multimedia information system. Currently we have only developed the collection repository part, and the conceptual modeling for the collection repository database is shown in Fig. 2.

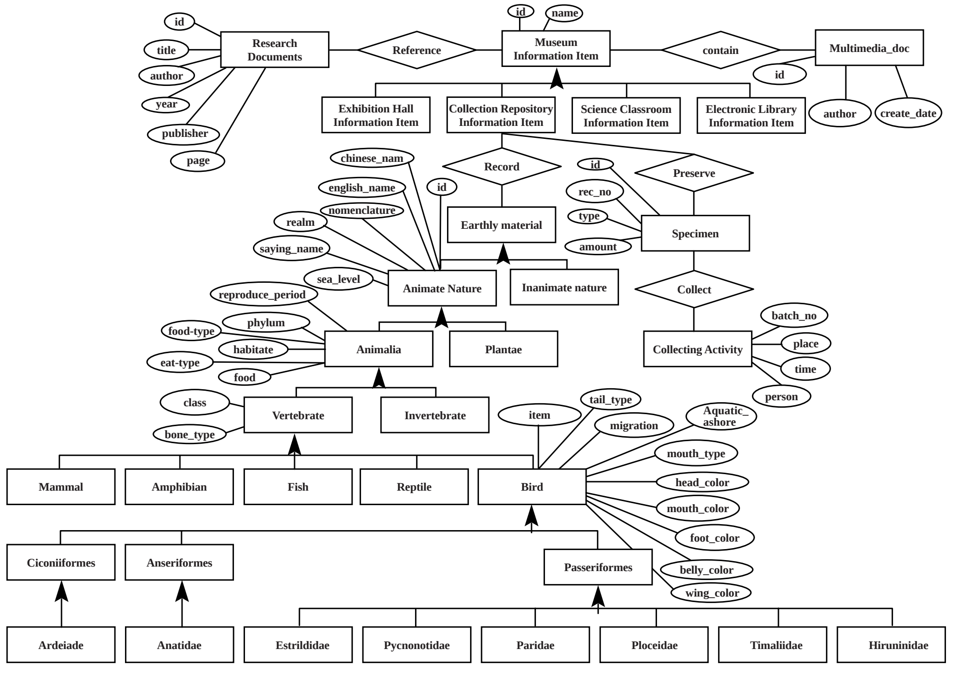

Fig. 2. System conceptual modeling.

A museum information item is a basic unit used in recording the intellectual assets of the museum. It can be used to describe an exhibition item, a book, or one kind of insect, bird, or plant. Each information item contains a group of multimedia documents for related subjects. The multimedia document modeling will be explained in the next section. Furthermore, the information item might refer to some research documents; thus, there is a relationship, called Reference, between the information item and research documents. The information item in the collection repository database has an IS-A relationship with the museum information item. In order to present the specimen for an information item in the collection repository, a relationship called Preserve is specified. For Earthly material, a hierarchical structure is built using a top-down approach. The hierarchical structure shows the generalization property between super-classes and sub-classes. The conceptual modeling shows not only the class hierarchy of an entire animate nature system, but also the inheritance of attributes between entities. The sub-class entities will inherit the attributes specified in the super-class entities.

3.3 Multimedia Document Modeling

Each museum information item can be described by several subjects which are presented with one or more multimedia documents. A multimedia document is a compound structure which integrates various monomedia (i.e. text, image, audio, and video) together as the basic unit for querying and presentation. Four issues must be considered when modeling a multimedia document; they are logical structure, content structure, spatial relationships, and temporal relationships [12,13].

Logical structure is used to partition the contents of a document using semantic rules defined by users and to offer critical information for querying and presentation. Content structure is used to describe the features of each component in a multimedia document. Spatial relationships are used to specify the placement and layout of various components of a document on the screen whereas temporal relationships are used to specify the synchronization requirements between media objects during presentation. In general, the synchronization problem can be solved in three respects: client end, network, and server end. Here, we focus on the server end where synchronization requirements are specified in the database schema. In other words, the synchronization requirements are considered when modeling a multimedia document. Using the EER model, multimedia documents can be modeled as shown in Fig. 3.

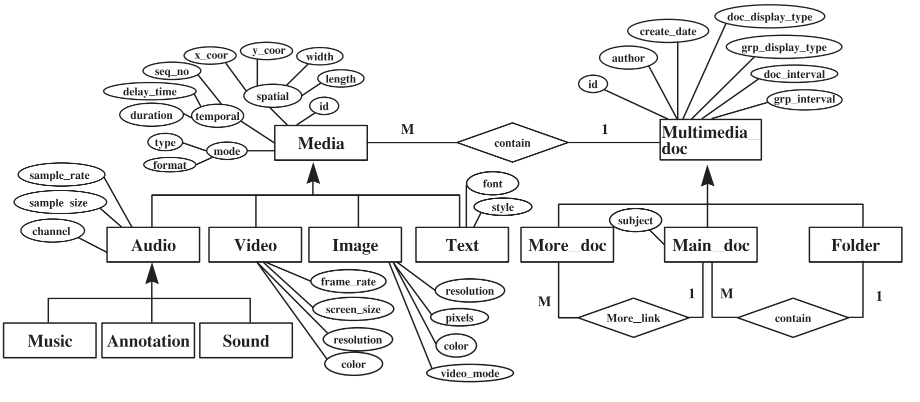

Fig. 3. Multimedia document modeling.

For the logical structure shown in Fig. 3, a multimedia document of entity Multimedia_doc contains a set of media objects. Entity Media can be modeled as a class hierarchy with sub-classes Audio, Video, Image, and Text. Further, entity Audio has a generalization relationship with sub-classes Music, Annotation, and Sound. For presentation, these media objects might be clustered into several groups, and each group is assigned a unique sequence number. Entity Multimedia_doc can be also modeled as a class hierarchy with sub-classes Folder, Main_doc, and More_doc. As mentioned in Section 3.2, each museum information item contains a group of multimedia documents for related subjects. Each subject has a corresponding Main_document which links to a set of related documents, called More_document. Main_doc and More_doc are their entity names, and More_link is the relationship between them. Furthermore, entity Folder can be viewed as a special Multimedia_doc. It has a relationship called Contain with entity Main_doc.

For the content structure of each monomedia object, we specify attributes for each monomedia type. The attributes of Audio are sample_rate, sample_size, and channel. The attributes of Video are frame_rate, screen_size, resolution, and colors. The attributes of Image are resolution, pixels, colors, and video_mode. The attributes of Text are font and style.

The spatial and temporal relationships between monomedia objects are very important during the presentation of multimedia documents. Some researchers have proposed approaches in the past [14,15]. Most models are relative, where spatial and temporal relationships are specified for each pair of monomedia objects. Thus, it is complex and perhaps time-consuming to model the relationships. Here, an absolute model is proposed. For spatial relationships, attributes Coordinate (including x_coor and y_coor) and Size (including width and length) are used to specify the location and space of each monomedia. For temporal relationships, we use attribute seq_no to specify the group of each monomedia, attribute delay_time to specify the starting presentation time of each monomedia within the group, and attribute duration to specify the presentation time of each monomedia. Within entity Multimedia_doc, we use attributes doc_display_type and grp_display_type to describe two presentation modes, i.e., manual and automatic, when presenting the documents on the same subject. For automatic presentation, we use attributes doc_interval and grp_interval to specify the presentation intervals between documents and groups, respectively.

4. BROWSING, QUERY, AND PRESENTATION OF THE MULTIMEDIA DATABASE SYSTEM

4.1 Browsing and Query Models

Large multimedia databases that store and manage multimedia objects must be equipped with robust high-performance interfaces for browsing and querying so that multimedia objects can be retrieved.

- ***Browsing***
  Starting with the highest-level objects, users can browse step-by-step until the target objects are found. Hypermedia documents are ideal for retrieval or browsing through navigation. Just as icons can indicate the existence of hyperlinked objects, various anchors can also be used in the hypermedia environment to browse other objects.

- ***Querying***
  Browsing might not be convenient for deep-level objects, i.e., objects nested several levels deep from the entry or the root, even if users know how to navigate. Often, users want to locate or browse objects based on the values of their attributes or features; for this situation another method called querying is proposed. By means of a query language or a visual query interface, users can specify the query predicate and send it to the underlying DBMS. After the database is accessed, all objects matching the specified predicate will be retrieved.

4.2 Browsing Mode

The major purpose of the browsing mode is to guide users as they navigate the system via conceivable symbols. Users need little knowledge about the scope of browsing, and do not need to input any data or conditions to the system. In our system, users are guided as they browse the database based on a top-down hierarchy. Users can click symbols (i.e. image icons or highlighted keywords) on the screen from the root; then, the candidate scope is narrowed down step-by-step after each click. Finally, the target node (i.e., a multimedia document) is found.

4.3 Query Mode

In our system, several user-friendly visual query interfaces are designed for various users. They allow inexperienced users to retrieve data from the database without having to learn a specific query language and help them understand the database schema. The specifications on the screen are attributes selected from entities which have been defined using the EER model. Users can select them from a pull-down menu or specify them directly. After filling up the input fields on the screen and issuing the request, the parameterized request will be transmitted to the server. Further, an SQL statement will be generated by the server automatically and submitted to the DBMS. Finally, the query results will be returned to the users. Then, users can inspect the results one by one. Four query criteria supported in our system are introduced in the following. Each method has its corresponding visual screen with query items.

- **Query by classification**
  In a particular domain, there might exist a classfication system which can be organized into a hierarchical tree. Thus, users may specify the nodes on the path from the root to any leaf in order. For example, animate nature exists a classification system; that is, realm, phylum, class, item, family, genus, and species. Users may specify each of them in the query. This method is particularly designed for users who are familiar with the knowledge of some domain.
- **Query by name**
  Query by name is the simplest query method. Users only need to specify the name of the target object which they want to view. The system will find the exact one for the user if the target object is in the database. For example, the user may want to view a bird called Little Egret.

- **Query by characteristic**
  Query by characteristic specifies a set of attributes representing the special features of entities. Then users can view some of or all the objects matching the predicates they have specified. For example, users may want to view birds with black beaks and yellow feathers. This method enables users to retrieve data according to their imagination or experience.
- **Query by SQL-like**
  Query by SQL-like enables users who know SQL but not the database schema to retrieve data easily. Users can select the class, the attribute, and the condition using the visual query interface, similar to expressing an SQL statement. The system will translate these specifications into an SQL statement and display the statement on the screen automatically.

4.4 Document Retrieval and Presentation Procedure

So far, we have discussed conceptual modeling and multimedia document modeling in the system. To retrieve multimedia documents, several browsing and query methods based on the visual user interface are also proposed. Now, it is necessary to describe the retrieval procedure from the client end to the server end. As shown in Fig. 1, each functional step in multimedia document retrieval [16] and the presentation procedure is as follows:

(1) A user specifies the target or predicates for a request (browsing or querying) using the visual user interface and then transmits it to the database server.
(2) The searching manager on the server end receives the request, then generates a corresponding SQL command and submits it to the DBMS.
(3) The searching engine of the DBMS will find all the multimedia documents matching the predicates specified by the user. The results will be passed to the object manager, which will organize them into a symbolic display format.
(4) The display format will then be sent to the presentation manager.
(5) The presentation manager will deliver the display format back to the user.
(6) The user can select one of the candidates and transmit the finer request to the searching manager again.
(7) The searching manager will submit the request to the DBMS.
(8) The target multimedia document will be retrieved from the database and sent to the object manager.
(9) The multimedia document will be transformed into a display format and sent to the presentation manager.
(10) Finally, the presentation manager will synchronize and send the display format back to the user, according to the spatial and temporal relationships of each monomedia.

5. IMPLEMENTATION

5.1 The Developing Environment

In our prototype system, the Alphaserver 2100 4/275 is adopted as the platform for a multimedia database server and Pentium 133Mhz PC's as clients. The server is connected to an FDDI bridge on the FDDI backbone (100 Mbps) via an Ethernet segment (10 Mbps). Clients can be inside the museum and be connected to another FDDI bridge via a multihub or a thick wire Ethernet segment. Another client can come from the Internet, which is connected to the FDDI backbone via a router. The developing environment is shown in Fig. 4. Furthermore, UniSQL, a relational and object-oriented database system, is used to design the multimedia database.

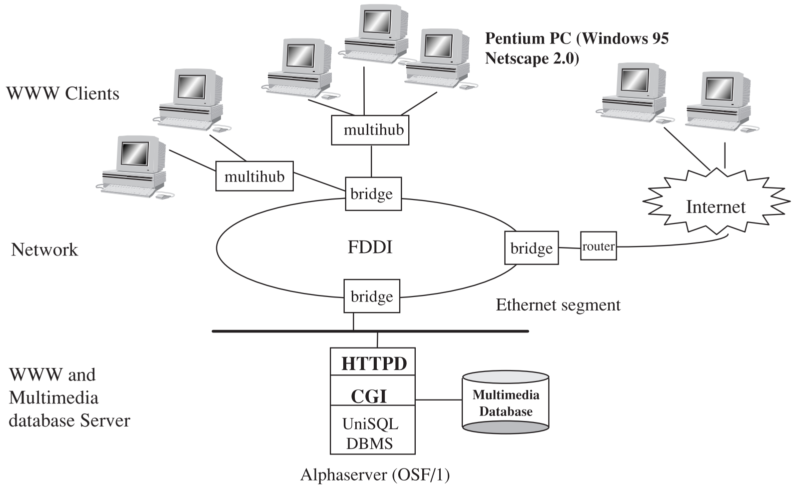

Fig. 4. The developing environment.

5.2 Visual User Interface and Document Retrieval

In order to provide a user-friendly browsing and query interface for users, multiple retrieval functions based on the visual interface are designed. The tableaus can be designed using the FORM format of HTML. Users need not have any experience with a query language and the database schema. They can simply select the attributes on the screen as a searching condition; these attributes are those defined in the classes of the database schema. The values of the searching condition can be assigned by selecting from a pull-down menu or by inputing manually. The users can select a retrieval function from the main menu as shown in Fig. 5 according to his/her requirement.

Fig. 5. Main menu of retrieval functions.

Five functions are supported by the system. The first one, Browsing, is the simplest one for users to navigate the database at will along multiple fixed routes. We use picture icons to represent information items in the system. Rather than inputing any information, the user can just click on one of picture icons that he/she wants to view level by level, and the scope will be narrowed down gradually after each selection. Finally, the user can reach the target document that he/she wants to view. From the target document, the user can navigate to get further information by selecting related subjects. This function is mainly designed for users who might not be familiar with computers or application fields. In Fig. 6(a)-(d), browsing from the root to the target document is shown. In addition, users can browse the related subjects highligted in the target document, as shown in Fig. 6(e).

(a)

(b)

(c)

(d)

(e)

Fig. 6. An example of Browsing.

The second function, Query by classification, is designed for researchers who are familiar with the classification property in a particular domain. A hierarchical tableau, i.e. a classification structure corresponding to a particular domain, is supported. For this function, users can input values for each item on the tableau according to classification information about target objects. An example of Query by classification is shown in Fig. 7.

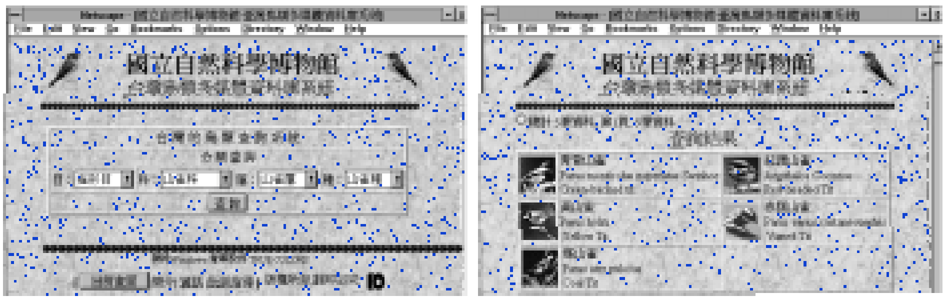

Fig. 7. An example of Query by classification.

The third function, Query by characteristic, is designed to find all the information items which match the characteristics specified by users. These characteristics come from the classes defined in the database schema. An example of Query by characteristic is shown in Fig. 8.

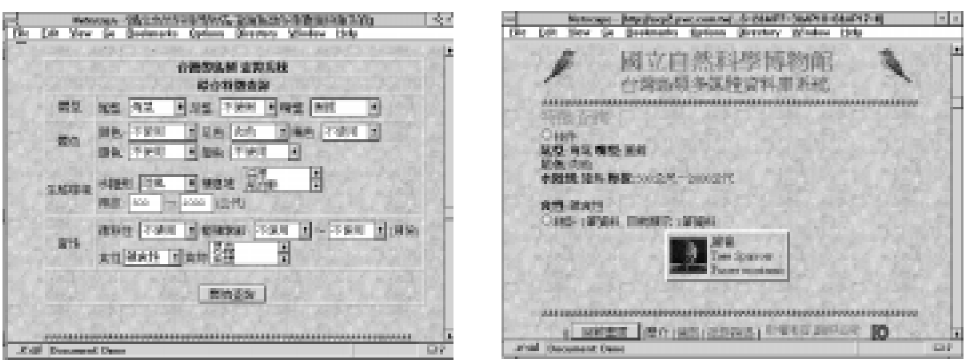

Fig. 8. An example of Query by characteristic.

The fourth function, Query by name, is designed for users who exactly or partially know the name of an information item. Based on the partial matching method, users can input a full or partial name in English or Chinese to ask the system to find all the matching information items. An example of Query by name is shown in Fig. 9.

Fig. 9. An example of Query by name.

The last function, Query by SQL-like, is designed for users who prefer to use an SQL statement. Users can submit an SQL statement from the SQL-like visual interface by selecting classes, attributes, and conditions on the screen. An example of Query by SQL-like is shown in Fig. 10.

Fig. 10. An example of Query by SQL-like.

6. CONCLUSIONS

The National Museum of Natural Science (NMNS) owns a large number of intellectual assets which can be utilized in the following four applications: Exhibition hall, Collection repository, Electronic library, and Science classroom. In the Collection repository, it is estimated that the total number of collected specimens will reach two million before A.D. 2000. In order to deliver the knowledge of these intellectual assets, such as alphanumeric records, documents, slides, photographs, photo CD's, video tapes, and audio tapes, to the world, we are digitizing them into digital forms of multimedia data. This multimedia data will be delivered to various kinds of users, such as the public, researchers, teachers, and students, according to their requirements. Obviously, a multimedia database server should be provided for users to query and retrieve the information items matching the specified predicates.

In this paper, we have explored the conceptual design and implementation design of the multimedia database. In the conceptual design, we have successfully applied the EER model to model both the multimedia information system and multimedia documents. For the multimedia information system, the hierarchy of animate nature and the properties of species have been proposed to support information management and query requirements. For multimedia documents, the features of content structure, logical structure, spatial relationships, and temporal relationships are also presented to support user queries and presentation. Furthermore, based on the visual user interface, multiple retrieval functions, including Browsing, Query by classification, Query by characteristic, Query by name, and Query by SQL-like, have been provided for various users to retrieve multimedia documents. Finally, WWW client/server architecture and UniSQL have been adopted to implement the prototype system, which will be the standard used to develop museum multimedia databases.

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Yin-Fu Huang (黃胤傅) received the B.S. degree in computer sciences from National Chiao Tung University in 1979, and the M.S. and Ph.D. degrees in computer sciences from National Tsing Hua University in 1984 and 1988, respectively. His dissertation research was concurrency control in database systems. He is currently an Associate Professor in the Department of Electronic Engineering, National Yunlin University of Science and Technology. During the period from July 1988 to July 1992, he was with the Chung Shan Institute of Science and Technology as an Assistant Researcher, and also was an adjunct Associate Professor in the Department of Information Engineering, the Tatung Institute of Technology. His research interests are database management systems, multimedia systems, performance evaluation, and operating systems.

Tien-Yu Hsu (徐典裕) received his B.S. degree in computer sciences from Feng Chia University and M.S. degree in computer sciences from National Yunlin University of Science and Technology. He has been with the Department of Information at the National Museum of Natural Science (NMNS) of Taiwan, R.O.C., as an Assistant Researcher since 1990. He also worked as a system engineer at the Digital Equipment Corporation in 1988, and was a visiting researcher at Purdue University, U.S.A., and at the Canadian Museum of Civilization, Canada, in 1995. Mr. Hsu is now heading up digital museum projects for constructing and developing multimedia database systems for collection, exhibition, and education at NMNS. His research interests include distributed multimedia, multimedia databases, and multimedia networking.