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# Computers and Advanced Technology in Education (CATE '99)

**May 6-8, 1999**
**Philadelphia, Pennsylvania - USA**

**Editor: M.H. Hamza**



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AUTHORS PLEASE NOTE
The registration fee for IASTED Members is $440.00 and for non members $480.00. Extra page and extra paper charges are $90.00 per page. The registration fee includes one copy of the proceedings, refreshments during the conference and the conference dinner on May 6, 1999. Cheques are to be made payable to IASTED. Visa and Mastercard are accepted.

PRESENTATION
Presentations are expected to take approximately 20 minutes, including a 5-minute question and answer period.

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# Database and Network Technology for Open Hypermedia Interactive Application Development

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## Abstract

The paper presents a methodology for an open Hypermedia Interactive Application System in the field of Historic Buildings. The methodology aims at enhancing the cultural value of historical buildings by offering students, visitors and experts an appealing and integrated overview, including some aspects which are often neglected. Both the methodology and its technological support tools provide a wide choice of reference categories and related data [building materials, historical information, environmental setting and risks, building and restoration techniques, etc.]. In addition, the system can be extended with new instances of data on buildings, construction materials etc. It is also highly flexible in that it can be used for instance for didactic and specialistic purposes, for historical and artistic analyses, and as an aid for restoration projects.

These results are obtained through the integration of database, hypermedia and network technologies which allow: (i) independence between data and presentation procedures; (ii) data "aggregation' around a wealth of categories and reference elements (eg buildings, monuments, building materials, environmental risk); (iii) system extendibility so that new instances of elements can be introduced; (iv) 3D displays for didactic purposes; (v) wide range of potential users and uses; (vi) data re-use, access to various network archives; all leading to a reduction in the costs of collecting, issuing and managing data.

Keywords: Hypemedia applications, network technologies, multimedia database, application reuse

## 1. Introduction

The availability of tools which enable the creation and manipulation of multimedia data has led to a wide variety of applications which use multimedia information. This is becoming a reality also in the field of Computer Based Training (CBT) and Distance Learning. The use of multimedia makes these applications attractive for the user, and very powerful in terms of information content. For example, while a CBT application that relies on textual data may only provide limited information, the combined use of text, audio, images and possibly video, greatly increases the possibility to stimulate users in information and knowledge "transfer". Interactivity is another means used to improve the usability of the application and its capability to help users not only to receive but to build up their own knowledge by themselves. In a previous work [1] we developed a hypermedia for correlating the main mineralogical features of building materials (various types of local rock, marble and stone) with how they were used in buildings and monuments in Tuscany. This research highlighted the stimulating and cultural nature that cross disciplinary studies (in our case mineral and architectural) have for students. The results encouraged us to

- overcome some of the typical limitations of applications that were conceived as ad hoc experiences (eg in the accumulation of new data), which restricted the potential inherent in the methodology;
- extend the area and aims of the application so that it can be used and exploited by remote stations with a wide variety of users (students, professionals, teachers, experts, visitors etc).

The main limitations of the first version were thus:

- The application was static in its content. As soon as new data become available, they cannot be made available to users of the application, but require a complete revision of the application.
- The capability of direct manipulation of multimedia objects and the support of user/system interactivity, although essential for effective applications, particularly for CBT applications, was very limited.
- It was conceived and developed for generic users. If the application has to consider all possible needs, it may become too complex and heavy; if it has to be simple and small, then it may not be satisfactory for many users [2].
- The cost for the development of different interactive multimedia applications could be quite high due to the

material, and for the organization of the material in the appropriate form in the application. This leads to the need to define and adopt techniques for the *reuse* of multimedia data and parts of the applications already developed. The problem of reuse of information has been addressed in [3], while the problem of reusing software components has been studied extensively [4].

Thus with the new version [5] presented here (for details see Sect. 2) we decided to make it:

- further reaching, more organized and richer in terms of categories and reference elements, of forms and representations, of the various types of data used;
- more organic and systematic so that materials and references could be extended quantitatively, a more scientific methodology could be given, and a more complete set of tools provided for facilitating its operation;
- make it suitable for organisations involved in safeguarding the cultural heritage as a data collection, update and exchange tool for organizing and managing their interventions, and
- cognitive tool, thus appealing to a wider range of didactic, specialist and scientific users and uses.

In fact, as detailed in Sect. 2, the system we present now allows users to personalize the application, by using only the information they need, and the learning paths they are really interested in. Furthermore, through the introduction of interactive 3D representations, the system offers a powerful descriptive and learning support, since it enables direct user manipulation of the material under study. Section 3 illustrates the system architecture and the technologies used to offer these functionalities. The final section discusses the lessons learned and outlines a few open issues.

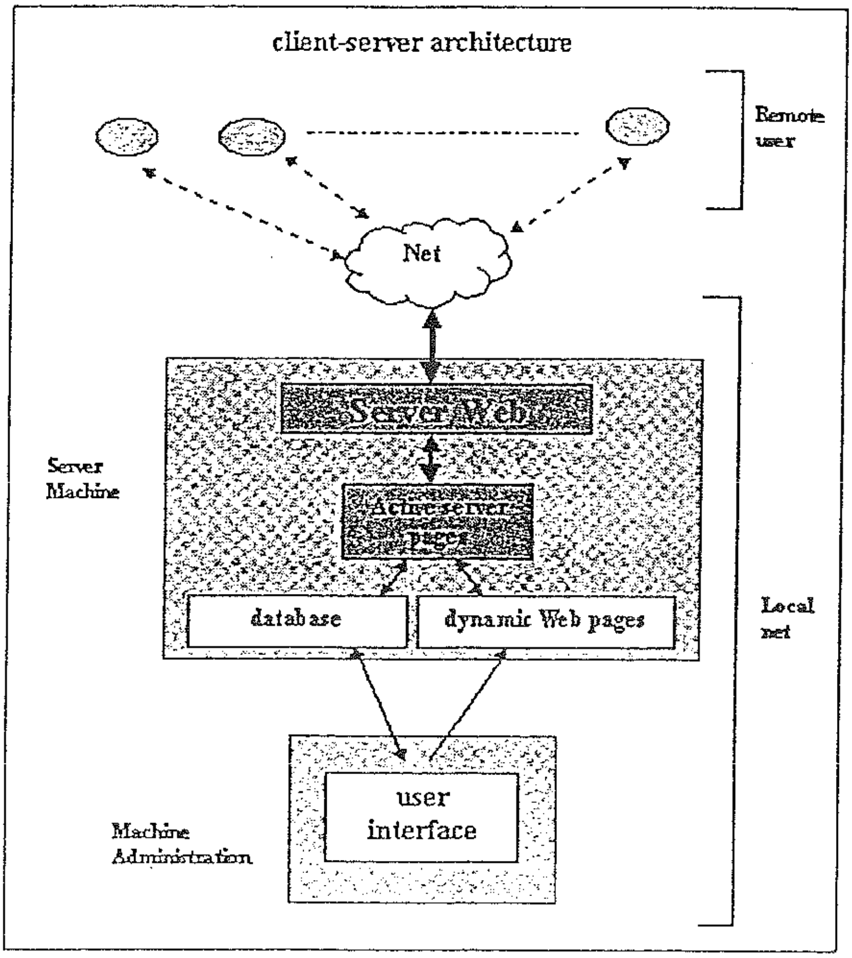



Figure 1 – The overall structure of the System.

## 2. An Open Hypermedia Interactive Application System

As mentioned in the introduction the main aim focused on here was to present a wide and extendible number of historic buildings and monuments located in a wide and extendible number of places in Italy. For each building and monument a broad range of choices is available relating to building materials and techniques, restoration, environmental risks (pollution, seismic, land conformation etc), conservation and safeguarding. The system was also conceived for a vast spectrum of users (students, teachers, experts, specialists, visitors, etc) who may have different interests (historical, artistic, mineralogical, etc) and may be accessing from different kinds of locations (from a building, monument, museum, remote, stand alone with CD, etc). Another important requirement was for the system to be easily organized and managed, particularly during any extensions due to inserting new data, buildings, building materials etc; with a clear distinction between what can be done by computer experts and non experts.

On the basis of these specifications aspects of Computer Based Training and Computer Aided Learning were integrated in order to develop:

- a methodology for the collection, acquisition, management and presentation of the data
- a set of tools and functionalities appropriate for making the methodology practically applicable and setting the system up

In the definition of the methodology by the organizations involved in safeguarding the architectural heritage, the types of data to consider were defined along with their characteristics and interrelations. In addition, the means of data entry, organization and presentation were also defined which were considered the most significant for the various uses, both from the point of view of management and from an informative, didactic and specialist point of view.

In conceiving the support system we considered remote use as our base reference, from which we could then define local and stand alone usage. We used a client-server architecture [see Fig. 1], in which a client from a remote station is connected to a server that can supply useful and relevant information when requested. The data at the server are stored and managed by a database that can interact with the processes related to preparing the presentation to send to the client by making available information dynamically and in the most recent version. This conception is shown in Figure 1 where the different [client, server, administration] roles are shown as explicitly associated with different [logical] "machines", though some or all of them may coincide within a single *physical* machine. In addition, Figure 2 highlights, also for administrators who are non computer experts, not only the individual categories of information but also how they can be combined and related for use. This logical schema is extremely helpful in showing in many different ways the data can be used, and how certain subsets can be identified as being relevant for the particular needs of a particular type of user (see Fig. 2).

This approach also means that various comparisons of particular elements can be made through displays in separate windows, which can then lead to an overall unifying reference area to stimulate client server groups to

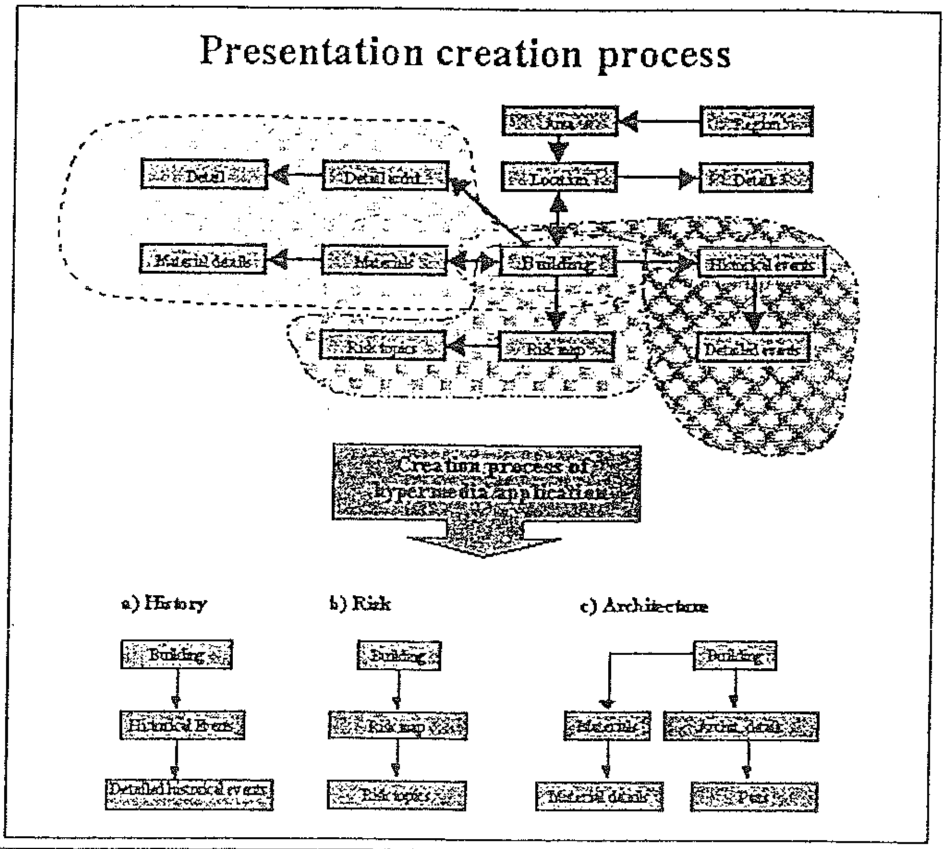



Figure 2 – The conceptrual schema fort the Hypermedia Presentation.

communicate and collaborate, and to allow managers from different sites to develop common means to making data uniform, and extending and presenting such data.

- Although there is a high number of categories of data considered, their individuality and mutual relationships can nevertheless be maintained stable

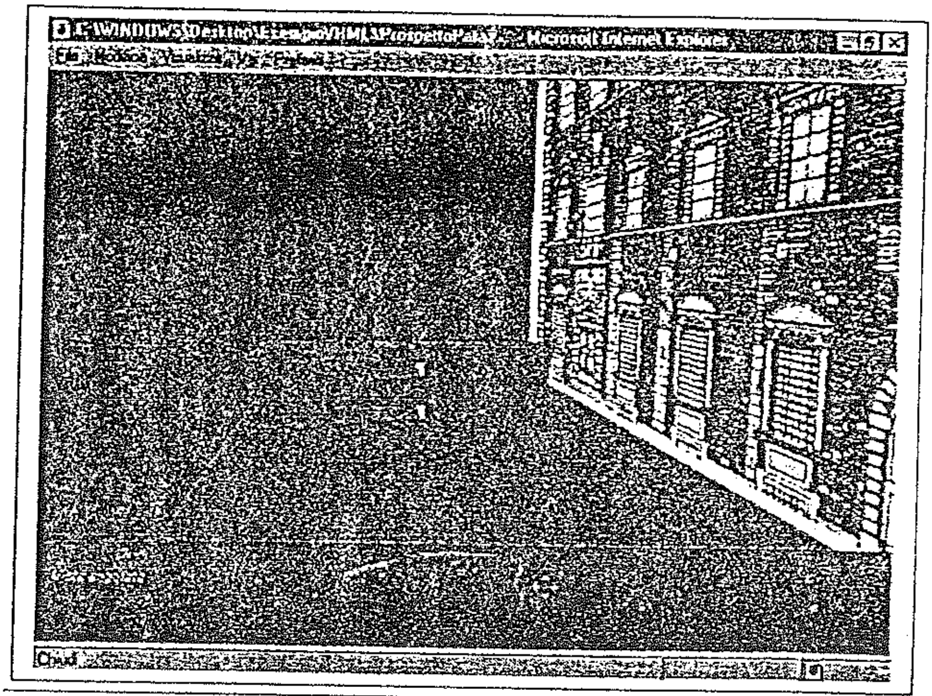


Figure 3 - The animated 3D model showing structural wall junction.

3D representations have thus been used to highlight specific architectonic and building aspects so that users will not only be involved in a process of manipulation and discovery, but cognitive as well as informative aspects will also be exploited. 3D models and representations (see Fig. 3) can be used during presentations to offer dynamic animations, so that the users can interactively manipulate (eg move, turn) structural elements in relation to a particular architectonic structure or building technique. CDs could thus be produced for stand alone use (eg in a museum), and standard operations could be tailored to the specific type of station available.

This solution has given rise to the following results.

- Data stored in the database are independent of the different presentation forms [and procedures], in the sense that the various pages required for a particular kind of presentation can be dynamically filled in with the relevant data dynamically retrieved from the database. While data are added or updated the presentation procedures can be maintained as they are, or new presentation procedures can use the same data already stored in the database.
- A true and clear re-use of data collected in the databases and possibly distributed over the network, for various uses in presentation.
- The system is open to new data and updates, which can be made systematic and easy through a friendly data entry interface offered for non technical users.

and clearly defined via a global conceptual schema [see Fig. 2].

- Suitable answers to a large variety of users [students, teachers, experts, visitors, etc.] are easily and clearly made via the global data schema, using its subschemas for specific presentation targets [building characteristics and details, historical analysis and evolution, materials employed and mineralogical properties, setting, and environmental aspects, etc.].

## 3. System architecture and technologies used

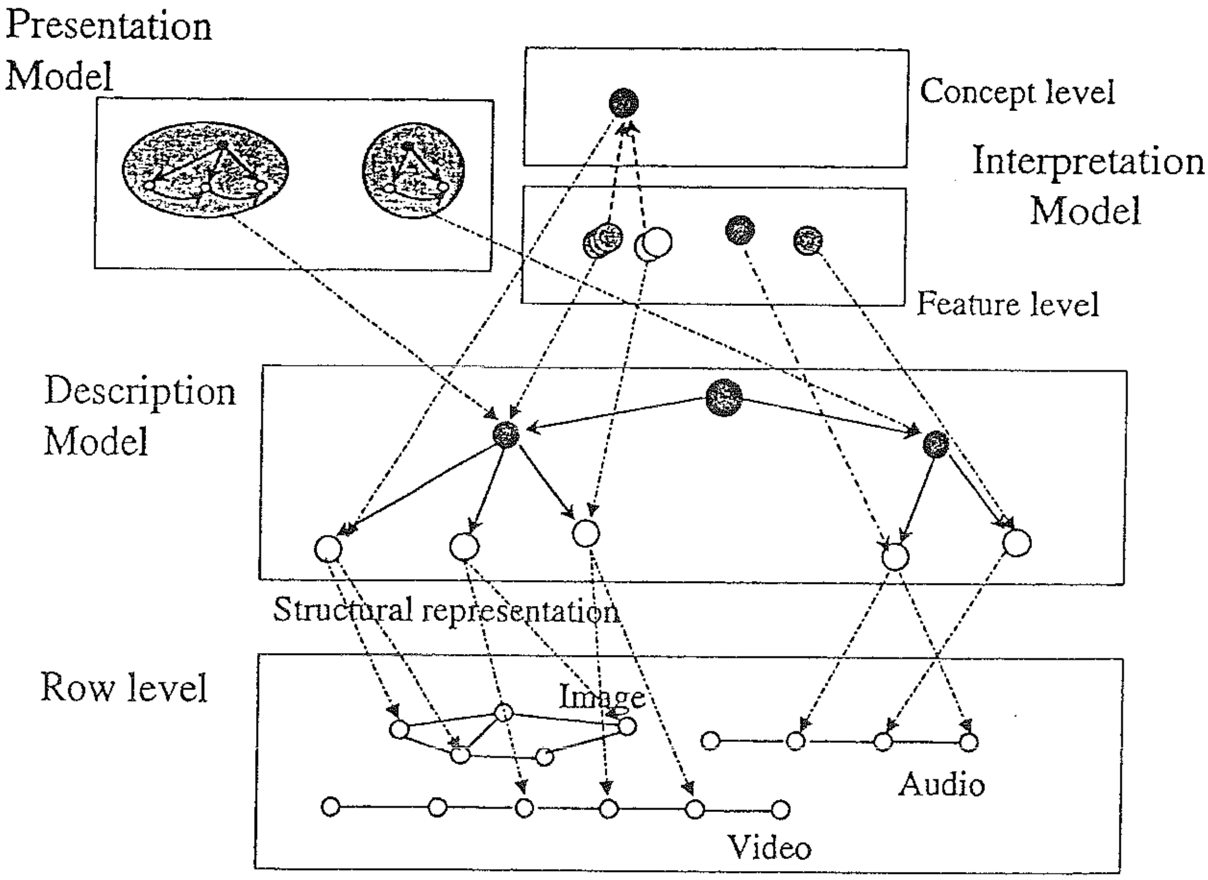
This section describes the system architecture that enables the separation of the application from the content, allowing the application to be updated as soon as new data are inserted into the database.

We also outline the characteristics of a system that supports a powerful description of multimedia objects, from raw data, up to their semantic content and rules for the composition of monomedia objects into complex and structured multimedia objects. This system can be used as the support for archiving and retrieving multimedia objects. In accordance with the overall system architecture already presented [see Fig.1], it is thus possible to:

- integrate the application by using the retrieval capabilities offered by the archive system,
- store and reuse parts of the applications,

* extract parts of the stored applications and of the multimedia objects and use them in other applications.

The simplest method for integrating the application and the database system (DBS) is obtained through a direct




Physical representation of Multimedia Data

reference in the application of multimedia objects stored in the database. For example, if the application needs to present a list of buildings (which are stored in the DBS), a reference to each of them can be included in the application. This solution is straightforward, but has the disadvantage that any insertion of a new building in the database, will require an update to the application. A much more powerful solution can be obtained through the content-based retrieval support offered by the DBS. In such a case, the application will specify a query issued to the DBS which allows all the buildings to be selected. The query is issued only when the user selects that particular page of the application: this solution implies that any new building added to the database, will be shown in the next run of the application.

One limitation is that the DBS system can select all and only the objects that are needed to the application; a powerful content-based retrieval support would greatly improve this approach. Furthermore, the retrieval support should not be based only on the attributes associated with each object in the DBS, but should also use the content of each multimedia object. We have thus decided to adopt the capabilities offered by the multimedia data model described in [6]. This model describes multimedia objects in terms of their physical characteristics, their structure, and their content. It consists of three parts: a *Multimedia Description Model* (MDM), which provides a structural view of raw multimedia data; a *Multimedia Presentation Model* (MPM), which describes the temporal and spatial relationships among different structured multimedia data and the *Multimedia Interpretation Model* (MIM) which allows semantic interpretations to be associated with structured multimedia data.

At the lowest level of representation, a *multimedia data* is any unstructured piece of information stored in the multimedia database. It can be acquired either from real world interfaces or from other existing multimedia databases. For example, a video sequence can be acquired through a video camera, an image can be digitized through a scanner, and so on. These are the ``real'' pieces of multimedia data, that we call *raw objects* (RO). ROs are the simplest elements that will be used in the applications: a piece of text describing a building, an image of a stone, a video showing a technique of construction, etc. However, at this level, the system does not have any information about the real content of these objects; furthermore, ROs do not contain any specification regarding internal content and internal structure. A portion of the data contains information about their physical encoding and the remaining data consist of an unstructured linear stream of bytes.

One of the aims of interpreting a set of persistent multimedia data is to make explicit the structure and content present in the multimedia data in order to support their retrieval. The interpretation uses abstraction mechanisms and relationships which are both generic, that is independent of the modeling needs of multimedia data, and specific for multimedia data. To express queries based on the content of objects, the *Multimedia Interpretation Model* allows the representation of the content of multimedia objects. The content is represented at two levels: the physical content is described by extracting features from multimedia streams, while a semantic description is obtained by associating object features with predefined concepts. The *Presentation Model* allows complex spatial and temporal relationships to be defined among description level objects in order to create multimedia presentations.

The objects which are interpreted and presented are identified by using the mechanisms of the *Multimedia Description Model.* It allows one to specify the structure and the composition of all the objects that the MMDS manages. In the Multimedia Description Model, the unstructured content of an RO can be conveniently structured by representing portions of it as *basic objects*, and then assembling such basic objects into a *complex object.* Objects of the Multimedia Description Model are those that can be retrieved, manipulated, and delivered. The values of features, which are defined and used in the MIM, are calculated for the objects of the description model, and queries are performed by using these features and their semantic description as arguments. Figure 4 shows how the model is organized.

The capabilities offered by a system based on this multimedia data model, offer a powerful support to content-based retrieval of multimedia objects, greatly enhancing the possibility to dynamically select the objects to be used in the application. This system also enables composite objects to be stored and retrieved: in particular, subparts of the application can be stored in the DBS for reuse. The functionalities offered also enable the selection of parts of the composite object stored. Finally, the system allows parts of raw objects to be selected and represented, thus enabling the extraction of relevant parts of the multimedia objects in order to use them in other applications.

We have presented a methodology and a technological system for the collection, update, management, and presentation of information related to the Architectural Heritage. We have focused above all on the didactic, specialist and culturally informative features. This system is characterized by the integration of hypermedia, databases and network technologies. It is open to new instances and updates and can be exploited for a wide range of uses and presentations.

Initial tests have confirmed the twofold interest that this system has for organizations that deal with the cultural heritage:

- ease of data entry and availability of useful and updated information for maintaining this heritage and for organizing any interventions in relation to it;
- use of the cultural heritage to its best advantage by stimulating various types of initiatives, eg didactic, specialist and cultural.

With regard to the second point, the system is particularly significant in its ability to bring together aspects that are often treated in isolation or completely ignored, along with the ability to tailor the presentation to users' needs.

Given the success of the project so far, we are planning to extend our research into finding ways of customizing the application and material, and to enhancing the management of several servers by interconnections on the network over all the region.

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