A Distributed Hypermedia on Archaeology in Tuscany

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Abstract

The availability of sophisticated network environments offers the possibility of implementing distributed hypermedia. The peculiarities of the cultural heritage data raise some challenging difficulties. The paper discusses some of these problems and the related solutions. Finally, it describes a project of a distributed hypermedia on the archaeological heritage in Tuscany, illustrating the first available results and the general system architecture.

Introduction

The cultural heritage constitutes one of the most suitable and challenging areas for the implementation of hypermedia applications. This is a consequence of the richness of interrelationships among the information items, and the variety of scientific and cultural interests peculiar to the potential users of such applications.

At present, there is a great enthusiasm in the field, and the expectations are augmented by the availability of the "information highways", which seems to make feasible the dream of every scientist, i.e. to have available all the information he/she needs, just accessing the right information point. Really, the more modern, generally available, network environments, seem to be a panacea for the implementation of a "distributed hypermedia". Internet, Gopher, Mosaic, Netscape, WWW are the new "magic words" (for an exhaustive description, see [CACM9408]).

However, the enthusiasm towards this very powerful technology tends to diminish the attention paid to some problems that have been realised since long time in more conventional applications. As a consequence, it is easy to start very ambitious projects just exporting the models tested in specific, small scale experiences. This approach will end in disappointing results and a waste of resources.

In this paper we present a project whose aim is to develop a distributed hypermedia concerning the archaeological heritage in Tuscany. The project implementation is supported by a set of grants offered by Regione Toscana.

In the following, we will describe the project, the basic design issues and the first available results, pointing out how the user needs and the peculiarities of the application domain led to the design of the whole system.

Description of the project

The main goal of the project is the implementation of a distributed hypermedia on the archaeological heritage of the Tuscany area.

As a first step, we concentrated ourselves on implementing a system whose aim is the reconstruction of the ancient environment of a town and its territory, by means of a diachronic analysis. The test site is the town of Cortona.

The overall architecture was designed considering the user requirements. We have to suppose that the user of such a system will be interested in accessing the information following different association mechanisms, that in turn, agree with different interaction metaphors. To take an example, let us consider the following sequence of steps:

a) identify a geographical area of interest;

b) obtain a list of the objects pertinent to the area;

c) select an object (e.g. a tomb);

d) ask for the objects found in the tomb;

e) select an object from the list (e.g. a vase);

f) get the descriptive card of the object and it's image;

g) look at the decoration: identify the painted subjects;

h) search for other subjects that can be related to them;

i) search for other objects "related by subject";

j) select an object from the list (e.g. a statue);

k) get the descriptive card of the statue and it's image;

l) look at other objects stored in the same museum;

m) get the descriptive card of an object and it's image;

n) ask for the map of the area the object has been found;

o) display the historical evolution of the area (administrative boundaries, site names, etc.).

It is easy to see that the process can continue, and similar steps, which model similar association mechanisms, can be taken more than once. It is also evident that for each kind of step, a particular interaction paradigm can result to be the more suitable. In some cases the user will get advantage from interacting through a map (geographical or topographical), in some other cases, he/she will take advantage from browsing upon a classification or iconographic thesaurus. In other cases, the appropriate metaphor can be a cataloguing card or a traditional search and retrieve interaction dialogue. Last but not least, a time scale metaphor can be the most suitable for some kind of analysis.

Needless to say, the previous considerations apply to hypertext/hypermedia applications irrespective of they are implemented on small, single user machines, or in much more complex, distributed environments.

In this project, the amount of the available information, and the consideration that the archaeological objects found during the excavations are presently dispersed across various museums, dictated the necessity of accessing at the same time data located in various sites.

The envisaged technical environment is therefore a client-server architecture, where the servers, located across the network, will be accessible through the Internet services.

The user is intended to be a scholar, or a curator of the cultural heritage, or simply a tourist having interests in the field. A major issue is to allow the user to operate following his/her most natural way of thinking.

Basic design issues

The whole project pays attention to some of the most relevant problems that we can face in implementing effective applications in the field. In the following, we will discuss some of them.

Data structuring

Art objects are quite complex. Strictly speaking, an object can range from a fragment of an ancient vase to a large archaeological site. Even for objects of similar kind (e.g. a statue and the sculptures decorating a sarcophagus) the way of representing their characteristics can be very different. In addition, objects show interrelationships (part of, contained in, designed for, etc.)

The definition of the data structure is based upon the national Italian standards, developed by ICCD (Istituto Centrale per il Catalogo e la Documentazione) and CNUCE, whose rationale and complete definition can be found in [Signore85], [Papaldo86], [Papaldo88], [Parise88], [D'Amadio89], [Massari88].

According to these standards, a central role is played by the object: the classification schema is based on three different kinds of objects: simple objects, complex objects, aggregation of objects.

A simple object is an object such that all his attributes are pertinent to the whole object, and no components that may themselves be considered cataloguing objects may be identified.

A complex object may be either a simple object whose parts, physically or conceptually separable, exhibit some interesting peculiarities as cataloguing objects, either a set of objects which may be referred by a specific name.

The aggregation of objects arises when several objects are correlated on the basis of some conceptual criterion, but no name exists which identifies the aggregate.

It is obvious that the components of a complex object may be either simple either complex objects, and so is as far as the aggregate objects are concerned.

Data structuring plays an important role in the exchange of data, too, as it requires the definition of standards at conceptual, logical and physical level ([Signore93c], [Signore94d]).

The physical level is the simplest to be agreed upon: almost everybody can agree on a physical medium. In the network environment, it becomes even easier to exchange ASCII files.

The logical level is simply the definition of a key for decoding the information contained in the physical support. The exchange format, in this context, may vary from the very simple "card image format" to some sophisticated format, like the MARC format.

Effective data exchange is possible only if a standard has been defined at the conceptual level: that is, when a model has been defined that allows everyone to share the knowledge of the world of interest.

Agreement at the conceptual level permits to understand the semantics of the fields, and may be seen as the fundamental step toward data integration, as is pointed out in [Signore84], while agreement at the logical level only permits to distinguish one field from another.

It is easily seen that, once the conceptual data model has been defined and agreed, the process of defining an exchange format is straightforward, and may be accomplished overnight.

However, even if the definition of a data model may be seen as the most relevant step toward the definition of an exchange format, peculiarities of art history data must be taken into account. A characteristic of this kind of data is their fuzziness, as the same concept (the name of an object, place, artist) may me designated in different ways, depending on the cultural background of the scholar. The problem is much more complicated that in a conventional business environment, as the normalization of data involves a great cultural effort, to reduce to a common frame different ways of thinking, each one based on valid and well-established cultural traditions.

As we will describe afterwards, the whole design relies on the formal representation of the data, making use of well-established database design techniques. We used the conceptual schema to fulfil several tasks: firstly, it has been mapped onto a relational database structure. Secondly, it constituted the basis for the design of the information nodes. Finally, it led to the identification of the existing relationships among the data.

Normalisation of the language

Cataloguing and retrieving information pertinent to art objects require the adoption of a normalised language. Apart some pieces of absolutely free text, the major part of the text is written making use of a normalised language, to avoid inconsistencies, false hits, missing documents in retrieval, and so on. A simple "authority file" of the allowed terms for each field constitutes a valid solution in some cases. For some fields, however, the only effective answer to the problem is arranging the terms according to their semantic relationships of equivalence, preference and hierarchy. To this purpose, we intend to implement a hypertext version of a figured thesaurus of archaeological terms. It could be very similar, at least as far as the basic interaction functions are concerned, to the thesaurus on heraldry described in [Aulisi90], [Aulisi91], [Signore92a].

Iconography

Iconographic description is a fundamental way of accessing information. Even more important, iconographic classification can help in identifying the possible associations among different works of art and putting them in the right conceptual context.

It often happens that different users can rely upon different thesauri. As a consequence, they tend to give a different mental organisation to the concepts. It is evident that the reconciliation of different approaches requires the identification of the equivalencies between the various representations in the adopted systems. Perhaps, an agreement may quite easily be found on very general iconographic categories.

On the basis of the previous considerations, the availability of a concept browsing interface becomes very relevant. This, in turn, requires to represent in some way the semantic knowledge of the specific domain, and this is traditionally done by means of a thesaurus, that models the semantic equivalence, preference and hierarchy relationships between the concepts.

In a following section, we will discuss the problem of navigation and selection of terms from a thesaurus, as a basic component of the user interface.

Spatial and temporal context

Every information is sig[illegible]ical context. In short, the problem of historical geography can be reduced to:

a) storing time-dependent information;

b) displaying maps containing time-consistent data.

For these purposes, a traditional thesaurus approach is unsatisfactory. The related issues have been widely discussed in [Papaldo89], [Signore89], [Signore90a,b].

In passing, we must stress that conventional Geographic Information Systems (GIS) do not adequately manage the time coordinate. If a line (a river, a boundary, a communication route, etc.) changes over time, even for a little detail, it will entirely be stored as many times as a single variation occurs, in many different and fixed information "layers." For a more detailed description of the time-related issues in Geographic information systems, see [Langran93].

The solution proposed, and tested in several environments, consists in the definition of a formal "external syntax" useful for representing the dates in a compact, semantically meaningful format. The uncertain dates can be represented, with all their fuzziness, as a fork, leaving to the scholar the possibility of identifying a "probable date", which can differ from the simple arithmetic mean of the two edges. Dates expressed in this format are easily stored in the underlying database, and all meaningful operations on the time intervals (overlapping intervals, excluding intervals, contained intervals, etc.) can be translated in appropriate relational language constructs.

In formalizing and storing the information, attention must be paid to the identification of time-dependent relationships and/or properties.

In the implementation of the system, we will rely upon a database that stores the time-varying relationships among the places, their past names, political entities, and so on. An appropriate *intelligent agent* will be in charge of interpreting the time operators in the user's query, translating them into appropriate relational queries, intercepting the results and formatting them in the external syntax format.

Structural vs. associative links

The complexity of the objects directly leads to the necessity of structural links among the information nodes that describe the single parts of composite objects.

As these links are inherent to the object itself, it is easy to represent them, eventually implementing the links directly on an image or map.

On the other hand, the richness of the possible associations necessary to put the objects in their historical and cultural context leads to an enormous number of possible associative links. These last links constitute the real value of an information system on cultural heritage, opposed to a mere inventory.

It is possible to implement this kind of links, that are intensional (i.e. do not have to be explicitly stored in the information nodes) making use of a separate level of navigation, where the user can go through the concepts tied to the specific information node, looking for other concepts, and going back to the level of the data instances ([Signore95b]).

Other implemented links are dictated by the relationships that can be taken from the conceptual database schema. Therefore, combining the different implemented links, it will hopefully be possible for the user to interact with the system "as he/she is used to think".

In other words, it becomes possible to implement the sequence of steps we outlined in the previous section, making possible to start from a single piece of interest (e.g. a small statue) and go to the place the object has been found, or to another object whose subject has an iconographic affinity with the current one, or to other objects that are stored in the same museum, and so on, without owing to pre-define all the links that can lead from one information item to another. Obviously, user can choose the different ways of navigating through the hypertext at his/her will, following his/her specific interests.

User interface

As we have pointed out before, accessing information pertinent to the cultural heritage is a very complex task, owing to the difficulty in the identification of the right concept to find, the approximation of the chronological intervals attached to the single object, the linguistic variants, and so on. Therefore, we had to carefully consider the need of implementing an adequate user interface.

The main features that characterise such an interface are the possibility of concept browsing, the activation of dynamic links towards other information nodes through the relationships existing among the concepts attached to them, the interaction paradigms. Finally, the ability of performing a semantic mapping among the different conceptual schema of the different connected institutions is of crucial importance.

Expanding some of the ideas that led to the implementation of other hypertext appications ([Signore93a,b], [Signore94c]), we gave much relevance to the available interaction paradigms. The user can interact making use of several metaphors, that can be combined, e.g., it will be possible to combine the spatial and temporal metaphors to put the information in the right context and formulate effective queries.

Figure 1 reports an example of a *map metaphor*, where the objets relevant to the current query formulated by the user are can be seen in their appropriate locations.

The *classification paradigm* is based upon *taxonomic links*, and allows the navigation through the concept space: from a single node the user will rise up to one of the concepts associated to it. Afterwards, moving across the relationships that map the domain knowledge, he/she can identify other concepts. From these, it is possible to go down again the nodes' space. This aspect is discussed in more detail in the next paragraph.

We carefully considered the problem of user disorientation, that is emphasized when moving in a distributed environment. The availability of a map of the reachable nodes, where the distance of the nodes is calculated according to the strength of the connecting link, emphasises the significance of the role played by the links and offers further navigation facilities.

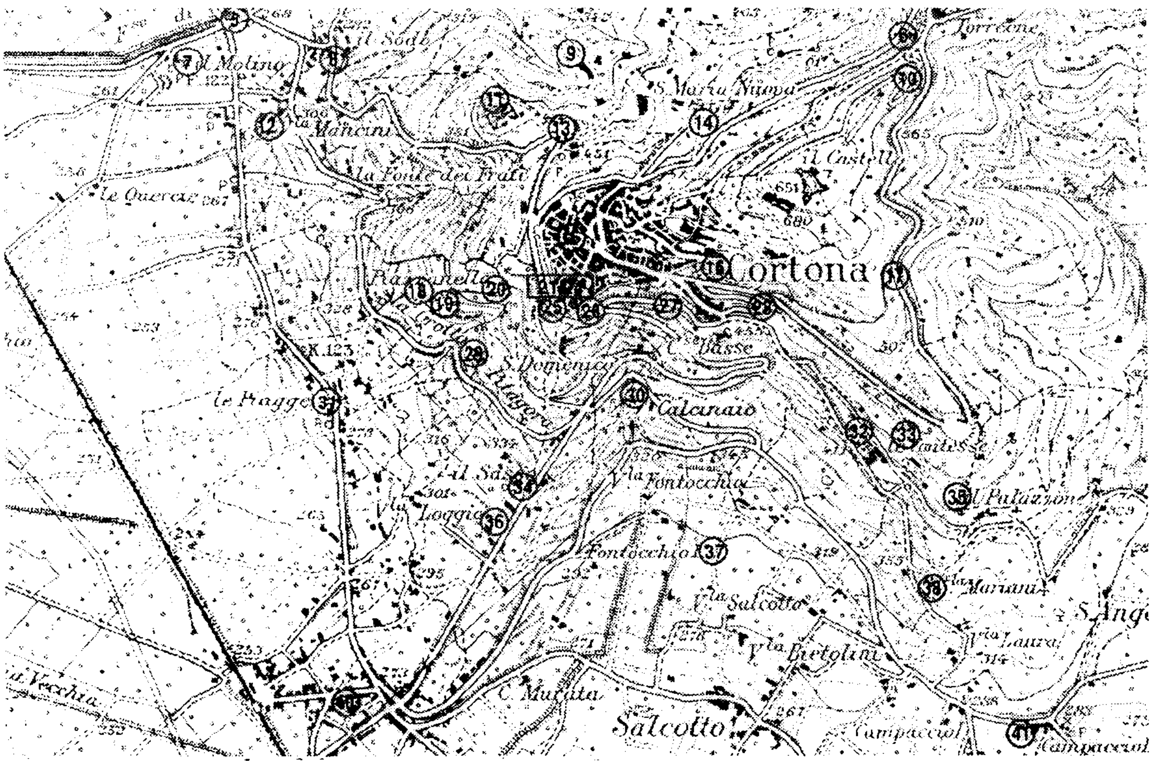

Figure 1 - An example of the map metaphor.

The thesaurus navigation

The most natural way of modelling the concept space is a set of thesauri. A thesaurus can be either tree-structured or multi-tree. In both cases, we can easily implement a graphical representation of the thesaurus as a graph, where the nodes correspond to the thesaurus terms, and edges model the connecting relationships.

Once the user has identified the kind of relationships he/she is interested to, he/she may select a term, and will have a display of a neighbour of the term, where only the selected relationships are shown. Purely hierarchical thesauri can be displayed as a tree, while for multi-tree thesauri a "butterfly display" constitutes a satisfactory metaphor (figures 2-3). In both cases, at user discretion, all the edges may be labelled with the relationship they are representing. The user can move around the structure (and ask for detailed explanation of the terms and/or an image) using the scroll bar, and may extend the tree toward the root or toward the leaves. Some examples of this kind of interaction can be found in [Aulisi91] and [Signore92b].

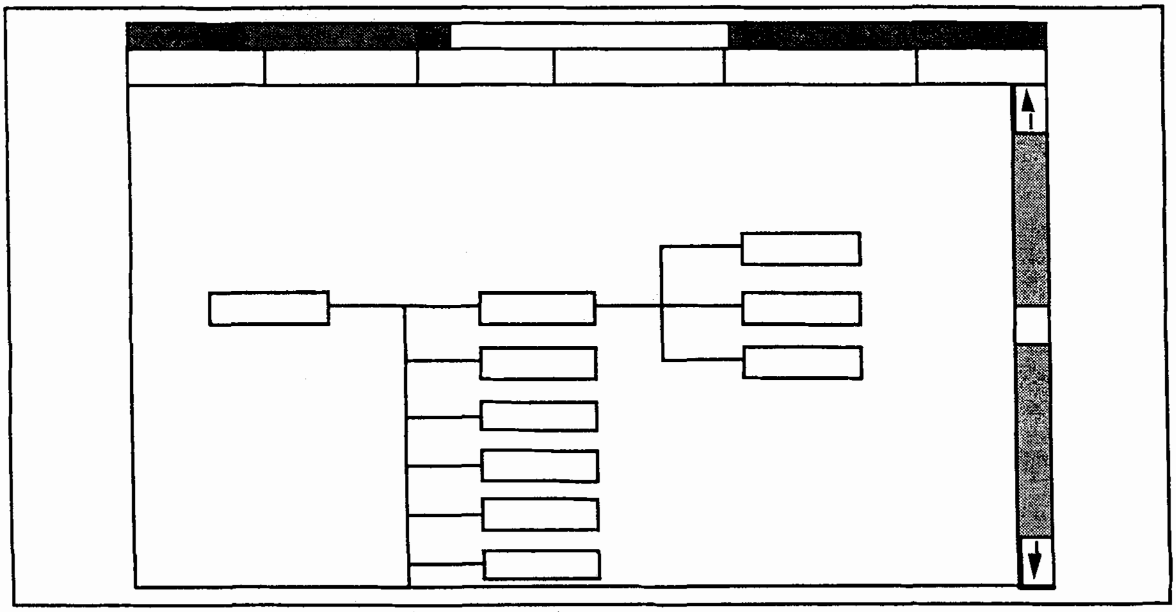

Figure 2 - An example of a graphical browser on a iconographic thesaurus (ICONCLASS).

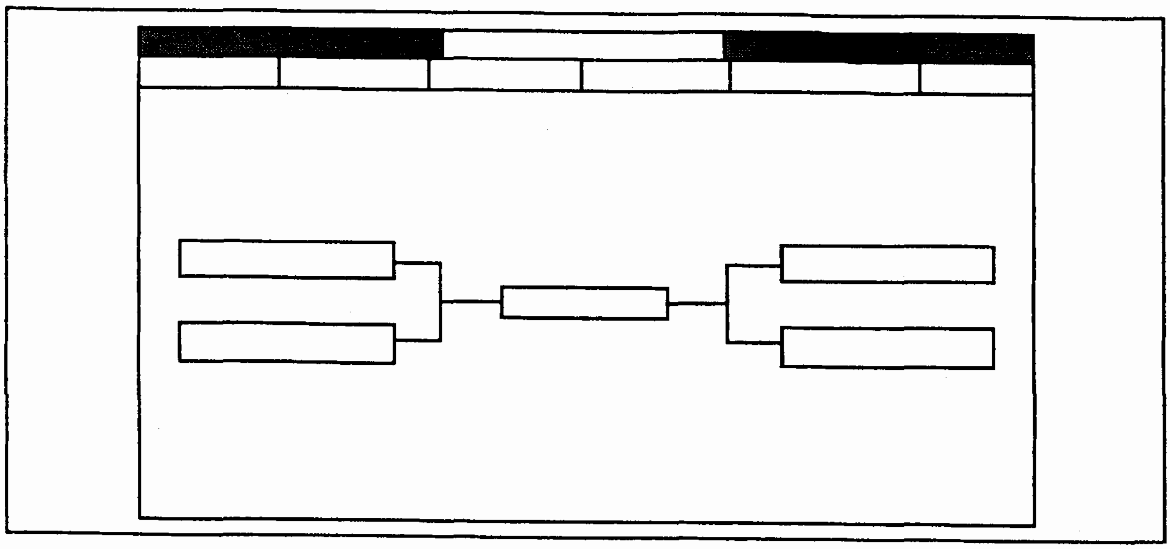

Figure 3: The *butterfly* display.

Preliminary results

We adopted a design methodology ([Signore94a,b], [Signore95a,b]) where the database conceptual schema plays a fundamental role to identify the layout of the information nodes, the suitable interaction metaphors, the implicit and explicit links.

As a consequence, the first step has been the design of a conceptual schema of the data pertinent to the archaeology, based upon the national Italian standards. Afterwards, we implemented a data entry, modelled on the conceptual schema.

The subsequent step has been the design of the architecture of the final system, which will integrate many ideas and approaches tested in previous experiences.

The Conceptual Schema

The adopted approach was essentially based on the standard methodologies currently in use in the conceptual database design area. As it is well known, the most popular approach is based on the Entity-Relationship model proposed by [Chen76], and the conceptual model is independent of the software and the hardware environment.

The first step has been the identification of the "basic" entities, like object, author, location, and so on. The identification of the relationships between these entities has been taken as the second step. This process led to a simple, consistent model, were the object is playing a central role.

It is easily seen that this approach allows to represent many different relationships, and, used as an interaction paradigm, can help the user in establishing unexpected associations. As an example, a book can describe a geographic location where an excavation has been conducted, and an object has been found just in this excavation. In this case, the relationship between the object and the book is "mediated" by several other connections, not necessarily known by the user or by the scholar which entered the data.

Looking at the schema, someone can wonder about the importance given to the author, which is normally unknown in the archaeological context, but we intend to stress that in this way the system is "open" to more general data. In addition, how could one manage the case when the archaeological site or object is the subject of an ancient engraving, whose author is known? In this case, we are in presence of a relationship object-object (the archaeological object and the ancient engraving), that both are relevant as "cultural" objects, and one of them is clearly related to the author.

The Data Entry System

The data entry system constitutes a prototype of one of the user interface interaction paradigms. We have four logical categories of data: Objects, Documentation, Authors, Places.

It is possible to insert information pertinent to a single object, and the relationships between different objects, as well as details pertinent to documentation (books, articles, manuscripts, ancient drawings, etc.) or geographic locations related to the object.

The data entry has been implemented in Windows environment, using the Access DBMS. The facilities offered by Access allowed to define forms tied to the underlying relational tables, with buttons to activate the data manipulation and retrieval functions, and windows for displaying data of the related tables. The windows sequence corresponds to the associations between the various entities in the conceptual schema, and has been implemented using the event based language Access Basic.

We made an extensive use of the integrity constraint checking mechanisms, like mandatory fields, range and foreign key constraints, delete cascade, etc., to assure data integrity at logical and physical level.

The System Architecture

The system architecture (figure 4) is articulated in four levels. At the *User Interface Level*, the user will interact with the system using the metaphor that he/she will think to be the most suitable: a map can help in finding data related by geographic or topographic neighbouring, a thesaurus browser can support the concept refinement phase, cataloguing cards will display in detail all the data pertaining to the objects found. At this level, a sophisticated hypermedia engine will support the implementation of the various and interchangeable metaphors.

At the *Information Interpretation Level*, a set of Intelligent Agents ([CACM9407]) will be in charge of fulfilling functions as concepts' refinement, information filtering, date conversion, masking or enhancing links, and so on. We suppose that the data will be transmitted according to a widely spread protocol, like HTTP, Z39.50, ISO Search and Retrieve protocol. Therefore, at this level, we will have a document parser, which will interpret the document, configure some dynamic links according to the user's profile, and so on.

At the *Conceptual Model Level*, we will have the semantic mapping between the user's perception of data and the underlying data model. In figure 4 we show, as an example, a very small portion of the conceptual schema, just to emphasize how the relationships modelled at this level can suggest the most appropriate metaphor. In this case, the presence of the relationship between the Object and the Sites

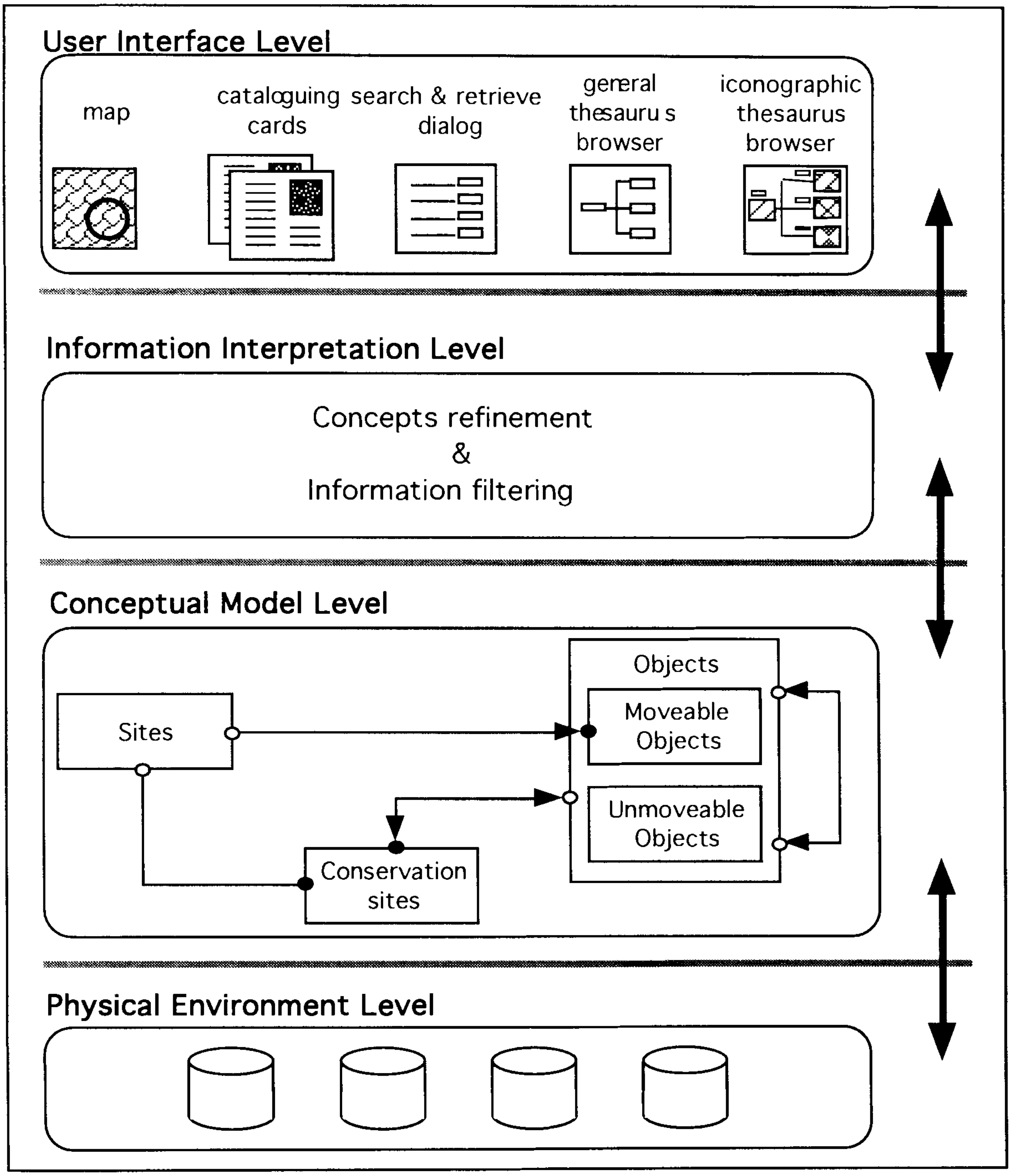

Figure 4 - The system architecture

suggests to use a map metaphor. The mapping between the various conceptual models on the various sites would take place at this level, too.

Finally, at the *Physical Environment Level*, we find the data servers, located across the network.

The proposed architecture should cope with the problem of making accessible data managed by heterogeneous software. Would a common conceptual schema be missing, it would remain possible, to a certain extent, integrate different data sources, searching for the appropriate trade off between the user expectations and the complexity of the agents.

Some modules of the proposed architecture have been already developed, and are going to be integrated in the final system.

Conclusion

The network environments offer the possibility of easily accessing data across the world, and therefore really offers the possibility of implementing a distributed hypermedia where textual data are integrated with images, sounds, videos, and so on. However, we must consider the inherent complexity of the cultural heritage data, which raise some difficulties that we would not meet in other, more conventional environments. Therefore, a distributed hypermedia on cultural heritage must consider the difficulties arising from the different cultural traditions of the scholars. This leads to the well known and widely debated problem of data structuring, common schema, spatial and temporal context, language normalization, thesaurus usage, etc.

After many years, and thanks to the large effort put by cultural organizations, scientists and scholars, many problems found a viable solution.

In this paper, we recalled some of these problems and the proposed solutions, and sketched the general architecture of a distributed hypermedia system, intended for the archaeological heritage of the Regione Toscana.

The system relies upon the availability of a conceptual schema, and its architecture is charaterized by the presence of several levels and of a set of intelligent agents. The user interface has been carefully considered, with the aim of implementing several interaction metaphors that should allow the user to move across the different data chunks following the mental associations that appear to be the most suitable or promising according to his/her peculiar interests.

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