Museum-on-Demand:
Dynamic management of resources in World Wide Web museums

Fabrizio Furano, Renzo Orsini, Augusto Celentano
Dipartimento di Matematica Applicata e Informatica
Università Ca' Foscari di Venezia
Via Torino, 155 - I 30173 Mestre (Ve)
(ffurano,orsini,auce@dsi.unive.it)

ABSTRACT: Given the problem of building virtual museums, this paper discusses the tasks of retrieving, assembling and presenting hypertext/hypermedia resources trying to surpass the limitations imposed by the World Wide Web. A virtual museum construction approach is presented, in which a comprehensive database and a complex system are required to perform such tasks in order to propose information and layouts tailored to the visitors' needs, make easier the museum's content maintenance and avoid data duplications.
KEYWORDS: virtual museum, World Wide Web, database, system.

1. Introduction

This paper presents a technical framework for the implementation of a Web-based virtual museum able to:

- Contain several representations of the same exhibit, each targeted to a specified purpose. The representations consist of images, 3D models, descriptions at different detail levels, technical data, etc., aiming at satisfying different categories of users.
- Propose several visit patterns (i.e., guided tours) suitable for different kinds of user, limiting the information replication by exploiting at high level information re-use.
- Make easy the museum's content maintenance, specially if it contains many exhibits, and improve the flexibility in data storage.

The first goal can be reached even with normal Web authoring tools, if considered alone; in fact, variants in the representation or in the details can be obtained by adding text and links to a basic hypertext structure. Even in existing Web-based museums, new information can be added without modifying the structure of the pages, by adding links to document chunks that display new material, or new presentations. Working this way, however, can create problems: the documents might become too big to transfer, reading them can be a long process, unsuitable for a first idea about the museum contents, and many users might be not interested in details, specially if they have to wait more for getting the whole document.

The solution to those problems consists in building more ways to visit the museum, as it is done in CD-ROM based museums, or in on-site kiosks. "Normal"

visitors could visit the “normal” version of the museum, while the others, e.g., the ones interested in more information, could explore an “advanced” version.

In a traditional, statically structured Web, this solution requires replication of many pages, thus increasing the amount of work necessary to build and to maintain the museum; similar problems arise when different tours share common items. The limitations of basic Web browsing functions force replication of the shared information.

To surpass these limitations, it's necessary to overcome the static structure of Web documents, and to start thinking of a virtual museum as of a complex system, based on a rich description of the museum structure and contents, that assures the consistency of the tours and of the information displayed with the visitor requirements.

2. Related work

The separation of the logical structure of a complex hypertext system from the content manipulation and presentation is not a new idea, and many models have been developed that exploit this separation as a key point for assuring proper behaviour and good maintenance of the applications.

Nevertheless, these models have been considered mostly in academic projects, with little or no attention in commercial software. As a result, very few products, generally delivered through CD-ROMs, allow users to walk through the information in a completely consistent while highly flexible way.

The distinction, at the level of node internals, between the content and its presentation leads to the notion of *perspective*. Present also in early hypermedia systems like Intermedia [YAN 88], it has been fully elaborated in the HDM model [GAR 93], a model oriented to the structured design of complex hypermedia applications. The perspective is the concept that supports different presentations of a same content, and extends in a consistent way from an entity to its components. Together with different categories of links (structural, application and perspective links) it allows the structuring of an application according to a number of user profiles that can dynamically change, while remaining coherent. The model has been used in designing new applications, and as a reference framework for the evaluation of existing ones [GAR 95].

The notion that a hypermedia is a way to manage relationships among information objects is the basis of the RMM design methodology [ISA 95]. This methodology, based on extensions to the classical entity-relationship model, appears suitable for applications in the field of museums and exhibitions, that show a regular structure for a domain in terms of class of objects with definable relationships among them. Our work, while related to this approach, is however directly based on a data model, upon which the access functions to the museum information are built.

The fruition of hypermedia applications is often based on the idea of guided tour [TRI 88], a predefined subset of information organised along navigation paths more or less constrained, that give the user limited control over the hypertext navigation, but provide easy interaction and, in some cases, configuration possibilities. They

have been exploited in many applications related to museums (or exhibits in general), and in educational applications.

Other models have been developed for designing hypermedia applications, the reader is referred to [CACM 95] for a thorough review.

The limitations of the documents delivery protocols (mainly the unidirectional, fixed link structure) have prevented the adoption of such models in the World Wide Web. The recent improvements in the technology for dynamic management of documents may now change this scenario, but the cost of building and organising large document collections, both in terms of development effort and run-time support, is still high. Hence the need for developing automatic tools based on solid formal models.

Several examples of Web site related to real or virtual museums have been developed, the most known being the Web Museum [WEB 97]. Initially developed as a subset of the Louvre collection, it has grown up to a large collection of paintings and information about authors. However, this structure and its flexibility in navigation and exhibit display is very poor, and does not allow users to tailor the visits to specific needs.

A quite good example of a really "virtual" exposition can be found in the Web site belonging to the Asian Art Museum of San Francisco, showing an exposition called "Mongolia: the Legacy of Chinggis Khan"[ASI 97]. This one is very interesting for:

- the care in the page layouts, although statically implemented
- the page structures (of tours, artworks, explanations, etc.), that are clear and well defined.

However, this quite big exposition has some data duplication since some artworks are present into different guided tours, and there is a unique visit pattern.

3. Designing a virtual museum

One of the goals of a virtual museum administration system on the World Wide Web is to allow visitors to follow flexible but coherent free and guided tours, through dynamic management of documents and resources. The objective of such a system is the construction on the fly of Web pages starting from exhibits, itineraries, descriptions and data, taking into account the preferences of the user. In the rest of this section, we present an overview of our proposal, which follows from these considerations.

The Web pages which build up the virtual museum can be classified in three types: the *initial page*, the *tour pages* and the *exhibit pages*.

The objective of the initial page is the acquisition of the user profile by allowing him/her to choose among the different opportunities provided by the system. This page proposes a predefined set of different visit levels, involving different interests, user expertise, interaction languages (if the museum is multilingual), etc.

While the initial page is static, the exhibit pages are dynamically assembled by the system according to the following elements:

- the interaction level chosen by the user at the entrance of the museum;

- the current itinerary of visit ("tour"), which determines the links present in the pages;
- the type of the content which, together with the interaction level, determines the page layout;
- the data related to the exhibit which is the actual content of the page.

An important characteristic is that tours are treated exactly like exhibits: they are assembled dynamically starting from the same set of information used for the exhibit pages.

The flexibility of the system behavior is due to the fact that it is centered around a comprehensive database which contains the information needed to dynamically compose the requested pages; these are then assembled and elaborated in order to assign them the context deriving from the path followed by the visitor.

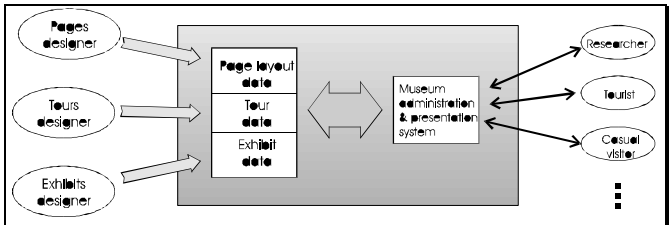

Figure 1. *Interacting entities and system structure*

In Figure 1 the overall structure of the system is presented. The main components are:

- the visitors, with different profiles;
- the virtual museum server;
- the museum data repository, which can be considered as composed by three levels, one for the basic information (exhibit data), one for the structure of the visits (tour data), and one for the page layout information;
- the persons who insert the museum data.

In our proposal, the persons who set up the virtual museum are grouped in three different roles:

1. the designers of the exhibit data base, who are concerned with the definition and insertion of information about the museums exhibits,
2. the designers of the visit patterns (guided tours, free navigation, and so on) who a re in charge of the tours contents and representation, and
3. the page designers, who define the Web pages layout and the correspondence between the page areas and the exhibit and tour data.

In the next section, we detail the structure of the database and describe its use.

4. The database

Figure 2 shows a schema of the data base proposed here as the core of a virtual museum. The schema is subdivided into functional blocks, corresponding to the three levels in the structure of the data. The schema has been designed for the object-oriented database language Galileo [ALB 85], and uses the following notation:

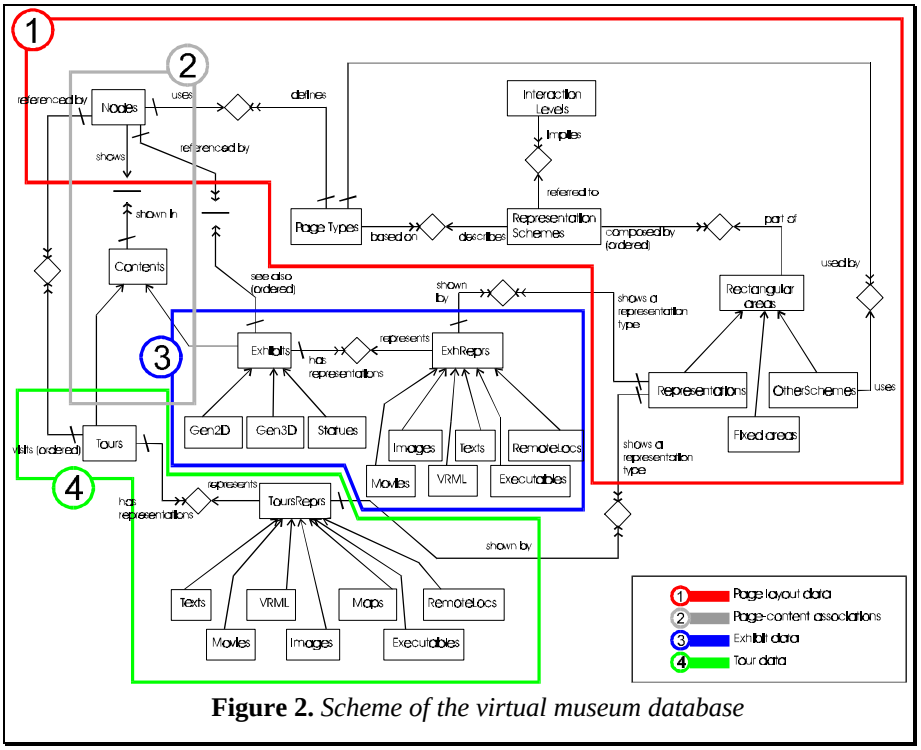

Figure 2. *Scheme of the virtual museum database*

rectangles stand for classes of objects, while diamonds stand for associations among them, like in the classical entity-relationship model. Subset of classes, or subclasses, are set of objects defined by specialization, and are linked to their superclasses. The arrows which enter in the diamonds indicate if an association instance has only one or more than one element related, while a cut in the arcs indicates a partial association.

Section 2 of the schema contains the information about the existence of the dynamic pages (*Nodes* class) and their content (*Contents* class, and *Exhibits* and *Tours* subclasses).

Section 1 of the schema, which contains the classes *Page Types*, *Interaction Levels*, *Representation Schemes* and *Rectangular Areas* (with their subclasses), is the part which handles all the information about data retrieval and presentation.

4.1 Exhibit level

At this level, it is important to distinguish between two different aspects of an exhibit: the *data*, which describes its characteristics, and the *representations*, which are different ways of presenting the exhibit itself.

The majority of virtual museums available in the World Wide Web shows an exhibit using a few representations, normally one or more images; we allow, instead, to have at the same time several representations of different types.

For instance, in our prototype these kinds of resources are supported: images, movies, VRML three-dimensional objects, texts, tables, resources generated by programs or real-time events, resources available in other Internet sites.

In the scheme it's visible the one-to-many association between the *Exhibits* class and the *ExhRepresentations* class, modeling that an exhibit can have more representations. The resource types that can be used as representations are subclasses of *ExhRepresentations*.

With exhibit data, on the other hand, we denote a set of information specifying various characteristics, such as author, dimensions, year, technique and so on. Those information chunks can range from very simple to very specialistic; the method proposed to store exhibits data consists in the memorization of the technical data of each type of exhibits in subclasses of the *Exhibits* class. Part of system software can access these data, format them in a standard way and insert the resulting text in a rectangular area of a page.

The subclass structure can be extended to accommodate additional requirements coming from specific types of exhibits, or from specific museums. In section 3 of the scheme is presented a simple set of classes (*Exhibits*, *Gen2D*, *Gen3D*, *Statues*) for an art museum.

Finally, since an exhibit can be, in general, related to other nodes of the musuem, both exhibits and tours, an ordered sequence of links to *Nodes* is maintained in the scheme by the many-to-many association “see-also”.

4.2 Tour level

The term *Tour* applies to every entity that can be displayed by itself, whose purpose is to maintain and make usable an ordered sequence of links to other pages of the virtual museum. This concept derives from the usual meaning of the term, but here it has a wider scope: it represents any type of path between pages, considered as a sequence of reachable stops.

Tours are treated as exhibits regarding their representation: this allows us to use in a consistent way different perspectives for them.

The ordered sequence of links to the nodes which consitute the tour is represented in the scheme by the many-to-many association “visits”.

It is important to note that, in our model, tours can contain links to other tours as well as exhibits: this gives a great flexibility in organizing the visit patterns.

4.3 Page Layout Level

The purpose of this part of the database is to keep all the data necessary to:

- define the interaction levels, that is the aspects relevant to the user choices,
- define the page types, that is the set of the possible layouts for the pages,

- link this information in order to get, for each request, the data that will constitute the content of the page to be sent to the visitor.

This level has, hence, two objectives: coordinating the retrieval from the database of all the information about exhibits and itineraries, and then presenting it in a standard form, defined from the needs of the exhibit (or tour) and of the visitor.

The objective of the section 1 of the scheme in Figure 2 is to formalize the classes interacting in the definition of the layout of the pages. From the needs of the page (*Nodes* and *Page Types*) and of the visitor (*Interaction Levels*), the other classes (*Representation Schemes* and *Rectangular Areas*) define the layout of the page and the data it will contain.

4.3.1 Representation Schemes

In the model, an element of class *Nodes* is an entity containing the information used to visualize an exhibit or a tour in an hypertext dynamic page. In fact, a node is associated both to a content (exhibit or tour) and to a page type, which defines the visualization characteristics for the content. In this way, the same content can be visualized in different ways if it is associated to different nodes.

Hence, the system uses a node to produce a page which is sent to the visitor's browser.

To understand such a process, we must discuss how the content of the page is retrieved and how the layout information are used to format the content.

In order to clarify this discussion, we will first introduce a few terms:

- *Page Type*: the page designer must define a set of types of pages, which correspond to the different ways of showing the museum contents, examples can be: *Normal Artworks*, *Big Artworks*, *Standard Tour*, etc.
- *Representation Class* : this term identifies the subclasses of *ExhRepresentations* and *TourRepresentations* containing the representations of the exhibits and of the tours.
- *Representation Type* : this is a key used to identify a particular representation of an exhibit or an itinerary, examples are: IMG (image), MAPPA (map), ICONA (icon), TESTO (text), etc.
- *Representation Scheme* : this describes the layout of a page as a bi-dimensional disposition of boxes (*rectangular areas*).

The way in which the representation scheme describes the layout of a page is through a sequence of rectangular areas ordered left to right, top to bottom. Each area has associated a number, which is the percentage of the space it is allowed to cover.

A rectangular area can contain: a) a sequence of representation types that the system can request from the node being shown; b) a page type, which, together with the current interaction level, is used to specify another subdivision of the area in smaller ones, c) a fixed part, which represents objects not depending from any exhibit or tour, generally used as fixed logos or navigation controls (Figure 3).

The model discussed so far has been implemented as a prototype in [FUR 97]. The prototype has been built using tools which are largely available in the development of web-based applications: *perl* as gateway language and *mSQL* as database server.

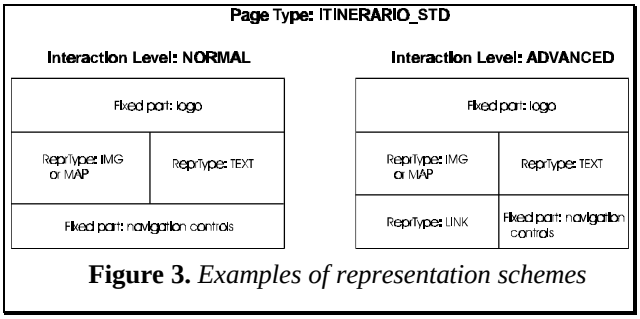

Figure 3. *Examples of representation schemes*

4.4 Sample museum construction

This section describes a small demo built as an example at Università Ca' Foscari, and visible at the Internet address http://www.dsi.unive.it/~ffurano.

Since the purpose of this construction is purely demonstrative, the museum is very small: 3 exhibits and 5 tour; i.e. 8 nodes, which can generate up to 14 pages. Data and exhibits representations were picked from the Web exhibition "Mongolia: the Legacy of Chinggis Khan" at the Asian Art Museum of San Francisco.

The possible visitors were first divided in two sets (the minimum number for a good test): normal users: interested only in looking at the most famous exhibits, following the guided tours available at the entrance of the museum and expert users, interested in all the content of the museum and all the itineraries, available at the entrance and elsewhere. The first set was associated to the interaction level called *NOR-MAL*, the second to the one called *ADVANCED*.

Figure 4. *Example of a page generated by the virtual museum*

The page types defined were one for the exhibits (called “OPERA_STD”), and one for the itineraries (called “ITINERARIO_STD”).

The resource kinds used in this example are: medium size image, client side map, icon, text description, link sequence, big size image and AVI movie.

A draft of the structure of each re-presentation schema is visible in Figure 3.

Once the visit of the museum has begun, the visitor interacts with the dynamically constructed pages in the same way he could with static ones. In Figure 4, for instance, it is shown the page corresponding to the Show-case 1 of the Advanced tour.

5. Evaluation and conclusion

In this paper we have discussed a technical framework suitable for implementing virtual museums on World Wide Web, aiming at satisfying three major requirements: rich variants in information content and presentation, different visit patterns tailored to user profiles, easy maintenance and flexible data storage. In this section we evaluate the proposed solution according to these requirements.

- **Information content and presentation**. Two aspects of the proposal contribute to satisfy this requirement: the use of a database from which the content is taken, and the dynamic layout of display areas.
  These aspects are not entirely new. Dynamic composition of Web documents is used at several extents in many applications, information retrieval being the most widely used case. Commercial products like Lotus Notes (with Web Publisher) and Domino [DOM 97] base document delivery on the translation of documents from a proprietary database format into HTML.
  In our case we take a step further, since complete documents do not exist *a priori*, but only atomic media components are stored. The degree of variants in Web pages content and presentation can thus be very high, and satisfy the requirements of a wide range of users. Proper design of the composition rules assures that the displayed information is consistent with the visitor expectations as defined in the user profile.
- **Different visit patterns**. In our proposal, the model used to define the navigation paths is the same used to build the rest of the museum. The same degree of flexibility and coherence we can assure on the museum content, can be guaranteed on the way the different museums items are connected.
  Two noticeable advantages come from the dynamic construction of navigation paths: the possibility of mixing standard and personalized guided tours, and the possibility of dynamically changing the visitor profile, thus moving across different layers of visibility of the museum structure, while retaining at each level the complete consistency of the navigation patterns.

- **Easy maintenance**. One of the features often underestimated in hypermedia application design is the ease of modification and update, and the possibility of reusing a whole application schema for a different situation. The amount of work needed to void an application of its actual content, and to populate it with new information, is often higher then expected, mainly when the content information is intermixed with the structural organisation and the navigation data. The coherent and constant use of a data repository whose structure is formally defined accounts for a decrease in the work needed to translate the application from one situation to another. The separation of the content from the presentation goes in the direction of reducing the effort needed. The database of media components (as opposed to complete documents) contributes to detach the definition of the information from the way it is assembled and delivered. The uniform management of document assembly and paths assembly makes the modification to either components a task that can be performed more easily than with the traditional approach.

Acknowledgement. The authors wish to thank R.Rabagliati for his contribution to the project.

6. Bibliography

[ALB 85] Antonio Albano, Luca Cardelli, Renzo Orsini, Galileo: a Strongly Typed, Interactive Conceptual Language. *ACM TODS*, 10, 2, pp. 230-260, 1985.

[ASI 97] Mongolia: the Legacy of Chinggis Khan, http://sfasian.apple.com

[CACM 95] Communications of the ACM, *Designing Hypermedia Applications*, Special issue August 1995, 38,8

[DOM 97] http://domino.lotus.com

[FUR 97] Fabrizio Furano, Strumenti e Metodi per la Progettazione e Realizzazione di Musei Virtuali, Master Degree Dissertation (in Italian), Università Ca' Foscari di Venezia, 1997.

[GAR 93] Franca Garzotto, Paolo Paolini, Daniel Schwabe, HDM - A Model-Based Approach to Hypertext Application Design, *ACM TOIS*, 11, 1, pp. 1-26, 1993

[GAR 95] Franca Garzotto, Luca Mainetti, Paolo Paolini, Hypermedia Design, Analysis and Evaluation Issues, *Comm. ACM, 38, 8*, pp. 74-86, 1995

[ISA 95] Tomás Isakowitz, Edward A. Stohr, and P. Balasubramanian, RMM: A Methodology for Structured Hypermedia Design. *Comm. ACM*, 38, 8, 1995

[TRI 88] Randall H. Trigg, Guided Tours and Tabletops: Tools for Communicating in a Hypertext Environment, *ACM TOIS*, 6, 4, pp. 398-414, 1988.

[WEB 97] The Web Museum, http://www.cineca.it/wm/

[YAN 88] Nicole Yankelovich, et al., Intermedia: The Concept and the Construction of a Seamless Information Environment, *IEEE Computer, 21, 1*, pp. 81-96, 1988