System Architecture for Tourist Orientation: The TOSCA High-End System

Luis Salgado, Enrique Rendón and Roberto Artola
Grupo de Tratamiento de Imágenes, E.T.S.Ing. Telecomunicación
Universidad Politécnica de Madrid, E-28040 Madrid, SPAIN
e-mail: lsa@gti.ssr.upm.es

ABSTRACT

This paper presents the architecture of a system to provide user orientation with the capability to automatically show multimedia information (audio, static images, panoramic images, VRML models, HTML pages) according to the user real or virtual location within a site. System architecture is based on Client-Server technology . Site related information is mainly located at the Server side. The orientation devices are the Clients which request information to the Server according to each user position, profile and, what it is more important, terminal capabilities. The proposed architecture has been applied to provide tourist orientation when visiting, either actually or virtually, an open-area of the city of Madrid named The Orient Square.

Keywords

Augmented Reality, VRML, Multimedia Information, Service Scalability, Client/Server, Java.

1 INTRODUCTION

The development of new cultural services to visitors, based on Information Technology, has represented a major issue in the strategy for Cultural Heritage. Particularly, orientation services to help the tourists visiting a site are widely demanded. Typically, the orientation devices provide information that helps the user to move within the site following a pre-defined path. Once the user has reached one of the pre-defined stops, he can request extended information about what he is observing (usually in audio format) prior to move to the next stop in his guided tour. Nevertheless, tourist orientation has to be understood in a wider sense: the user may decide to move freely within the site, not following any pre-defined path, and the orientation system should also provide him with relevant information according to his current location to help him to get oriented. In this last case, the position of the user within the site should be automatically detected as it drives the information delivery.

In this work we present the architecture of a system to provide user orientation with the capability to automatically show information according to the user real or virtual location within a site. This point is clearly a main difference with most of the existing tourist orientation systems. No user interaction would be needed as, from the knowledge of the user current position and orientation, the system automatically determines the relevant site information to be displayed. On the other side, this functionality is kept together with the more common offering of pre-defined tours to the user.

System architecture is based on Client-Server technology [1]. Site related information is mainly located at the Server side, named *Information Server* (IS). The orientation devices are the Clients which request information to the Server according to each user position, profile and, what it is more important, terminal capabilities. These capabilities, understood as terminal hardware capabilities, are taken into account in the system design to constraint the type and nature of the information that is presented to the user. This consideration led to the identification of a set of Client prototypes which fill the natural functional evolution path from the most simple to the most complex tourist orientation system, i.e. the one including graphics/audio and all sort of multimedia HTML based information [5]. Functional scalability of the proposed architecture is fully achieved.

To test the above-mentioned prototypes, an integrated system architecture has been proposed within the Esprit Project 26800 **TOSCA** (1998-2000): Tourist Orientation and Support in Cultural Assisted Tours. It conforms the core of the so-called High-End System. A unique framework holding all the information to fulfil the different Client requirements has been developed. The information provided to each Client is filtered according to its particular capabilities, although it is delivered by a unique central system called the Information Server. Particularly in our implementation, the Server has been filled out with information from a central area of the city of Madrid called The Orient Square. It is a big square surrounded by two relevant buildings: the Royal Palace and the Madrid Opera House called Royal Theatre.

2 TOSCA HIGH END SYSTEM GENERAL DESCRIPTION

It is a Client-Sever system composed by two different but perfectly integrated elements named: the TOSCA High-End Multimedia Personal Terminal Client (h-e MPT Client) and the TOSCA Information Server (IS). A general block diagram of the system is presented in Figure 1.

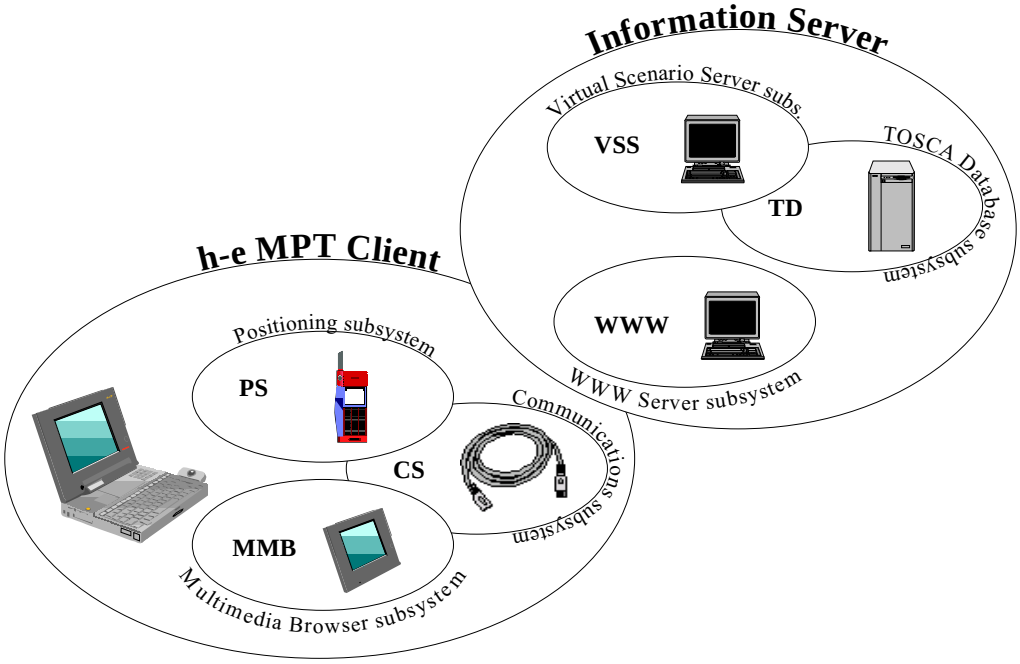


Figure 1: TOSCA high-end System main blocks diagram

As it can be observed, the h-e MPT Client is conformed by three different subsystems: the Multimedia Browser, the Communications and the Positioning subsystem. The h-e MPT Client is in charge of requesting cultural information from the IS associated to the user current position (detected through the Localization subsystem). This cultural information is mainly visual and audio information (either images or graphical models) of the site surrounding the current position of the tourist. Access to other type of information (mainly HTML based) is also possible, obtaining details related to specific cultural objects in the current point of view. The TOSCA IS handles all these requests. The needed communications are carried out through the Communication subsystem based on standard network protocols.

On the other hand, the Information Server is composed by another three subsystems: the Virtual Scenario Server, the TOSCA Database and the WWW Server. The IS is in charge of processing the requests coming from the h-e MPT Clients in order to build the necessary queries to the so-called TOSCA Database. All the information related to graphic models, textures and particular cultural objects extended information, will be loaded in the TOSCA Database so that the needed queries can be easily handled. It is important to stress the fact that there is a unique Information Server, designed to serve transparently requests coming from different h-e MPT Client prototypes. It holds all the information and, depending on the Client prototype (including the prototype identifier), only the appropriate part of the information is transmitted.

As far as possible all the developments carried out for both, the h-e MPT Client and the IS, are based on standard technology, trying to keep platform independence. To test the system architecture functionality regardless of some subsystems particular hardware implementations, software simulations have been used based on Java [3].

3 TOSCA HIGH END SYSTEM FUNCTIONAL DESCRIPTION

All the operations that a user (tourist) carries out on the TOSCA h-e System form an entity called *Session*. There are three different Session states: Session initialisation, Session execution and Session closing. Both, initialisation and closing are states whose functionality is common for all the implemented prototypes. For the Session execution the situation is different, as part of the involved operations depend on the particular functionality and type of information supported by the prototype.

3.1 System general operation

Here, only the common operations for the five different Client prototypes are introduced. Particular functional aspects of the Session execution will be presented later when focusing on each Client prototype.

3.1.1 Session initialisation

It establishes the connection of the h-e MPT Client with the TOSCA Information Server. It is implemented through an HTML form designed to ask for some information identified as:

- **User profile:** information that identifies the user (tourist) accessing TOSCA. Only the field related with the language in which all the information has to be presented to the user

has been considered in the implementations. It clearly affects the interaction with the TOSCA database in the Information Server side.

- **Terminal profile:** this information is provided through the selection of the prototype to be used. The type of information and how it is presented to the user is handled according to the Terminal profile (Client capabilities directly related to the available hardware in the Client).
- **Service profile:** this information is related to the type of orientation service requested by the tourist. Two concepts were considered to define the service profile:
- **User placing:** There are two possibilities for the TOSCA prototypes to work: In-Site and Off-Site. The In-Site mode is when the user is actually walking around the site using TOSCA to get information. In this case, a specialised hardware in the User Terminal would be required to let the application know automatically the current location (position, orientation or both) of the user. In order to test the system functionality independently on this specific hardware, positions and orientations are simulated through sensitive maps within the Positioning subsystem (Figure 1). The Off-Site mode is when the user is not actually walking around the site but is just using the TOSCA system to move inside a virtual site and get information (this could be, for instance, inside a Tourist Office).
- **Tour mode:** There are two possible Tour Modes: Automated-Tour and Guided-Tour. When the tourist is using the system in Automated-Tour mode, he is free to move wherever he wants inside the Site. The system in this case gives him information about the place where he is at a given time. In Guided-Tour mode, the system leads the user to follow a pre-defined path conformed by a number of stops. Once the user has finished visiting one of the stops, he may press the "Next Stop" button on the User Interface so he/she will be guided to the next stop. For the particular situation of a combination of Automated-Tour in the case of Off-Site, the tour is called Self-Tour.

Once this information is available, information associated to the Site is transferred from the Information Server to the Client. This information allows the Session execution to start.

3.1.2 Session closing

The client interface is closed when the user presses the finalisation button. No interaction with the server side is necessary for this operation.

3.1.3 Session execution

The first information transferred from the IS is a text file in which all the relevant elements of the Site (streets, buildings, squares, gardens, etc) do have a unique identifier. Also, associated to each relevant element, links and pointers to the available information is included. The organisation of this information allows finding the correspondence between the position of the user at each moment and the relevant information associated to it that can be found in the database. The information offered to the tourist depends on the specific h-e MPT Client prototype.

3.2 H-E MPT Client prototypes: functional description.

Five different prototypes of the client software, which incrementally add new functionality, have been developed. In the following sections a functional description of these prototypes is introduced following a bottom-up approach, i.e. from the prototype holding lowest functionality to the most complex one. The information provided to the user in the different prototypes is organized as presented in Figure 2.

The screen layout has been divided into three areas:

- *Visual Information Area*. Images of the relevant areas, buildings or objects are displayed on this screen area depending on where the user is located or what the user is looking at.
- *Text Information Area.* Position (Where the user is) and orientation information (What the user is looking at?) are presented in text format.
- *Buttons Area*. User interactivity is allowed through buttons that dynamically appear depending on the information available at each position.

3.2.1 Elemental prototype

In this prototype, all the information provided to the user is associated only to the user position, but not to the user orientation. Therefore, it does not require automatic detection of orientation. The information provided to the user is:

- "Where am I?" it informs the user about the place where he is located (i.e. name of the street, square, garden...). This information is provided in text format.
- "Images" associated to the position (not orientation) of the user. They are displayed automatically on the screen.
- "Audio" information (mainly cultural information) associated to the images displayed on the screen.

In case of Automated-Tour mode the photograph shown on the screen is selected depending on the position of the user. In case of Guided-Tour mode the photograph shows the user the next position of the site he should move to. This image should correspond to a place visible from the current point of view of the user. When the user arrives to the target position, the system automatically notifies (via text) it to the user. Once the user decides to continue the tour, he has to press the "Next Stop" button on the interface. The image corresponding to the next point to be visited within the site will be displayed.

Screen Layout

The particular use of the three different areas (Figure 2) within this prototype is as follows:

Buttons Area: Two buttons appear, the "Audio Information" and "Next Stop". The first one will become active when audio information associated to the current position of the user is available. The second one will become active once the user has reached the target position in a Guided-Tour.

Figure 2: Intermediate prototypes Screen Layout.

Text Information Area: Information about an object where the user is placed at (the name of the street or square), or information about the different stops in the Guided-Tour is displayed. It also notifies to the user when he has arrived to the Next Stop.

Visual Information Area: Photographs that correspond to the user position are displayed.

3.2.2 *Orientation-enabled prototype*

In this prototype the available location hardware in the Client is supposed to provide not only position but also user orientation within the Site. Therefore, new functionality is added with respect to the previous prototype:

- "Where am I?" and "What are you looking at?" text information is always available on the screen. Now it is possible to display the name of the object the user is looking at. In the example of Figure 2, as it is displayed in the Text Information Area, the user is looking at Royal Palace.
- "Area Map" of the Site indicating the current user position. This Map is displayed upon user request through the so-called "Map/Photo" button appearing in the Buttons Area**.** This button allows switching between the current displayed photographs and the "Area Map".
- In Automated-Tour mode the photographs shown on the screen are selected depending on the objects that the user is looking at (position and orientation available). As in the previous prototype, the audio information button will be presented on the Buttons Area when appropriate.

3.2.3 *Panoramics-enabled prototype*

This prototype adds the possibility to display Panoramic Images to the functionality implemented by the previous prototype.

A Panoramic Image is an image that a wide view of part of the site and it includes several relevant objects for which particular information is available in the Information Server. Figure 3 show the screen layout when a Panoramic Image (particularly a south view of Orient Square) is displayed. The relevant objects are highlighted through rectangular bounding boxes (three in Figure 3). The user is allowed to "navigate" among these highlighted objects using two buttons: the "Shift Object" button to change the focus of attention among the different relevant objects, and the "Select Object" button to access the information available for a specific object. The focus of attention is represented by a thicker bounding rectangle in red (in Figure 3 corresponds to the central building. The availability of a Panoramic Image depends on the user position and orientation. The "Select Object" and the "Shift Object" buttons become active only when the user is walking on the panoramic area.

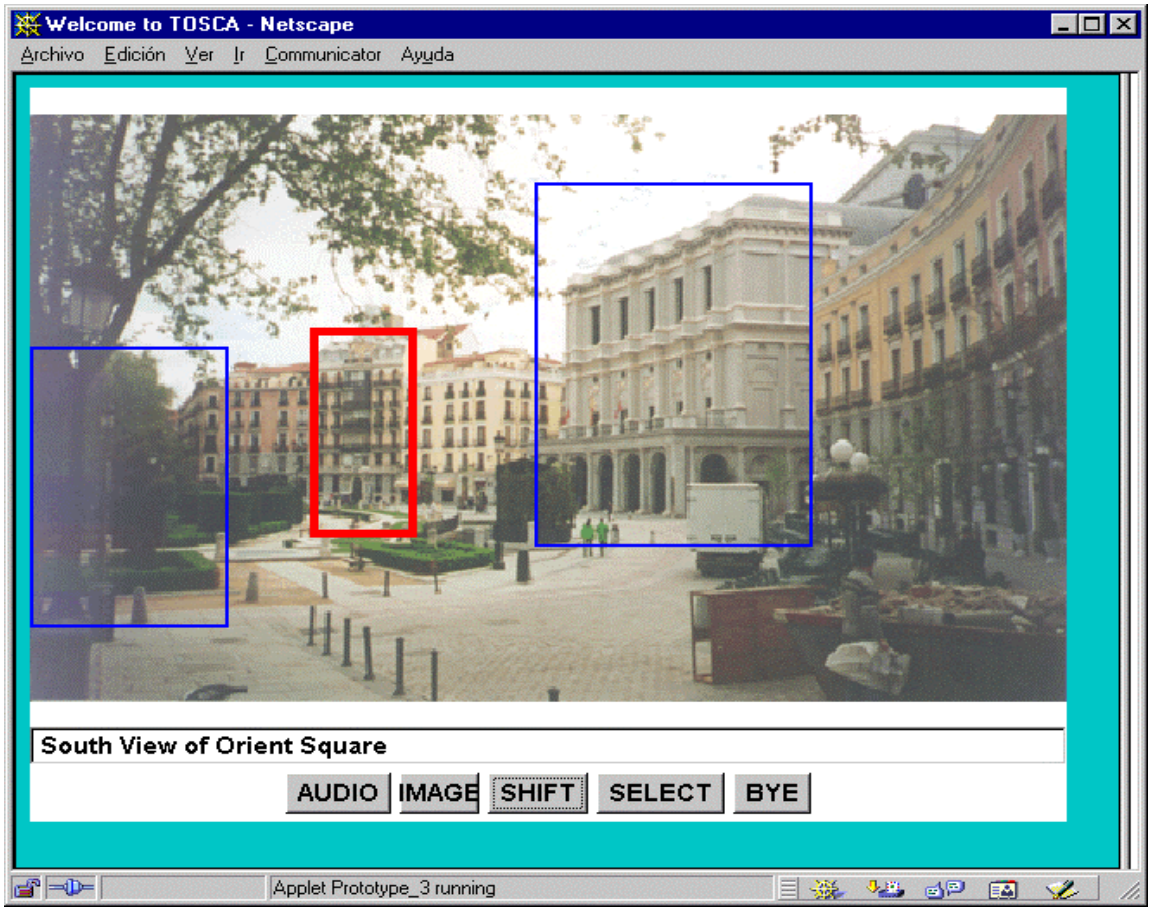


Figure 3: Panoramics-enabled prototype. South view of Orient Square.

3.2.4 HTML-enabled prototype

In this prototype full access to the network is provided, allowing free HTML navigation when HTML information is available for a relevant object of the Site. HTML information has been classified as "Cultural" or "Services" information. For example, when the user is looking at the Royal Palace in Madrid, "Cultural" information associated to it could be an HTML page holding historical details and pictures of the Palace. On the other hand, "Services" information covers opening and closing hours, available Guided-Tours, contact phone numbers, ticket prices, etc.

The Screen Layout incorporates a new area: HTML web browsing windows where HTML cultural and services information is displayed. As for other types of information, the availability of HTML information is shown to the user by activating the specific button, although it is displayed only upon the user request (clicking the button).

3.2.5 Fully functional prototype

Virtual Reality models are gradually introduced in many internet based applications as a way to improve user interactivity providing highly user-friendly interfaces. This prototype provides to the user a high quality three-dimensional virtual reality reconstruction of the Site so he can move through a Guided-Tour or an Automated- Tour, using controls provided in the prototype.

The user is free to move within a VRML based 3D reconstruction of the site in case of an Automated-Tour or is driven following pre-defined paths in case of a Guided-Tour. Once the user approaches a relevant object within the site, the system displays buttons to access the different type of information available. Figure 4 shows the screen layout for this prototype. As it can be observed, the main window is divided into two frames, the right one holding VRML information and the left one holding HTML based information. Particularly in the Figure, a view of the Royal Opera House of Madrid is presented. This example corresponds to the system working in Guided-Tour mode: the system is guiding the user following a pre-defined path. The icon identified as Next Stop (it represents a walking man with an arrow) should be clicked to be smoothly moved within the virtual reconstruction of

the site. When the user position is closed enough to a relevant object (for example, the Royal Theatre in Figure 5), the system automatically shows textual information with the name of the relevant object observed by the user (Royal Theatre) together with several icons. These icons represent the audio, services or cultural information that is available associated to what is being observed by the user. Clicking one of these icons will produce the retrieval of the information to be properly displayed to the user.

Considering In-Site tours, the user actually walking within the site, the posibility to use all the capabilities associated to this prototype is directly related to the type of device the tourist is handling. Many technical problems related to terminal weight, compsuntion, screen lighting, computational power, graphic acceleration availability and very particularly, band-width requirements if (as expected) need still to be solved to take advantage of all this information. Nevertheless, the posibility to have augmented reality through 3D virtual models becomes specially atractive for archeological sites or when models do correspond to ancient views of the same buildings the user is facing. This way the system can provide additional information to what the user is observing.

On the other hand, this prototype is extremely useful in Off-Site tours. In this situation, the user can plan a visit directly accesing the most relevant cultural objects through a virtual tour, either moving freely or being guided within it. VRML possibilities are fully explored [2]. Additionally, internet conection is allowed through the HTML frame so, interacting within the virtual model can provide access to services web pages directly maintained, for example, by cultural entities. Terminal capabilities are not a problem in Off-Site tours as most of the already mentioned technical problems are solved with conventional home computers with adequate graphic accceleration.

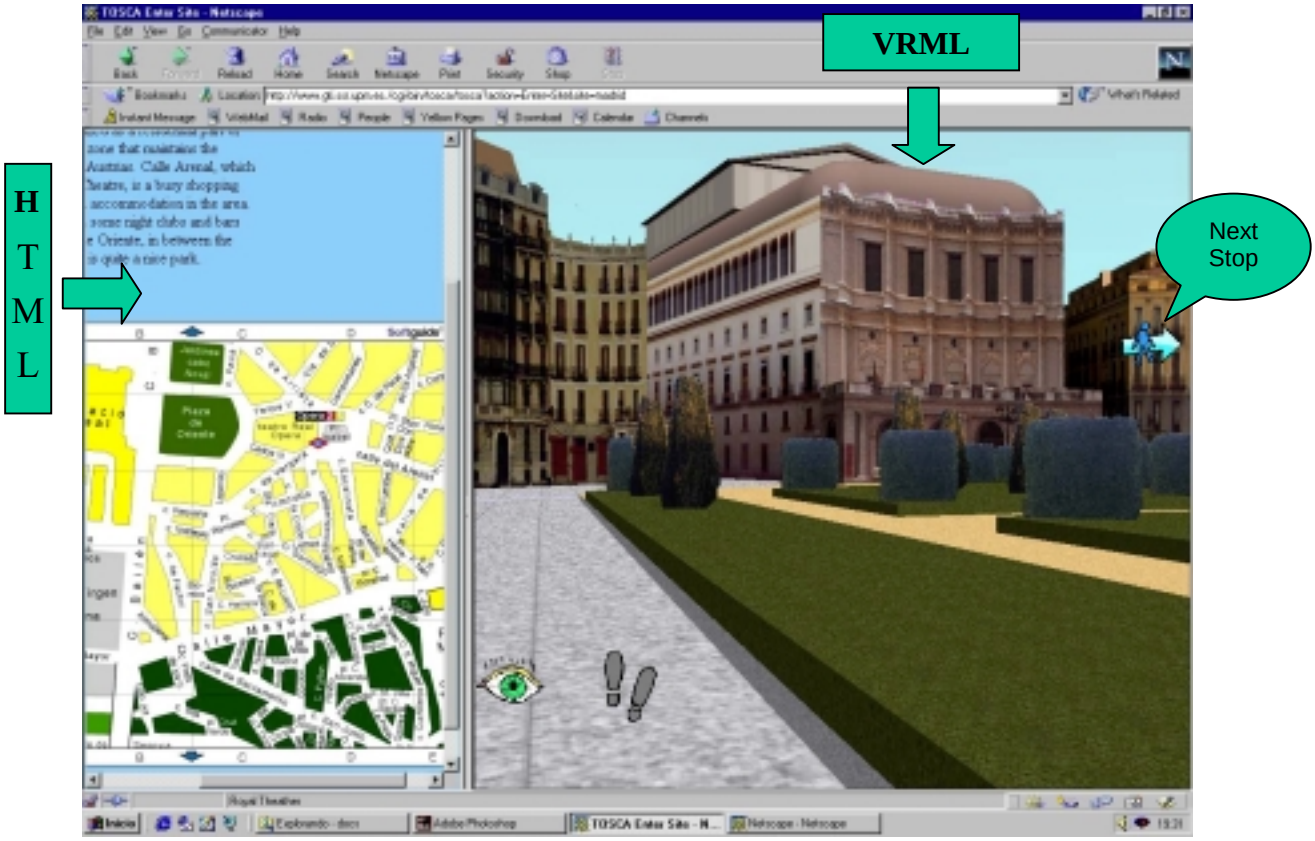


Figure 4: Screen Layout for the Fully Functional Prototype.

4 TOSCA HIGH-END SYSTEM ARCHITECTURE

As presented Figure 1, it is a Client-Sever system composed by two elements: the TOSCA High-End Multimedia Personal Terminal Client (h-e MPT Client) and the TOSCA Information Server (IS).

4.1 H-E MPT Client Architecture

Figure **6** presents a block diagram focused on the architectural components of the h-e MPT Client. As above mentioned, the h-e MPT Client is conformed by three subsystems (in Figure **6** each subsystem corresponds to one column), each one divided into different functional modules.

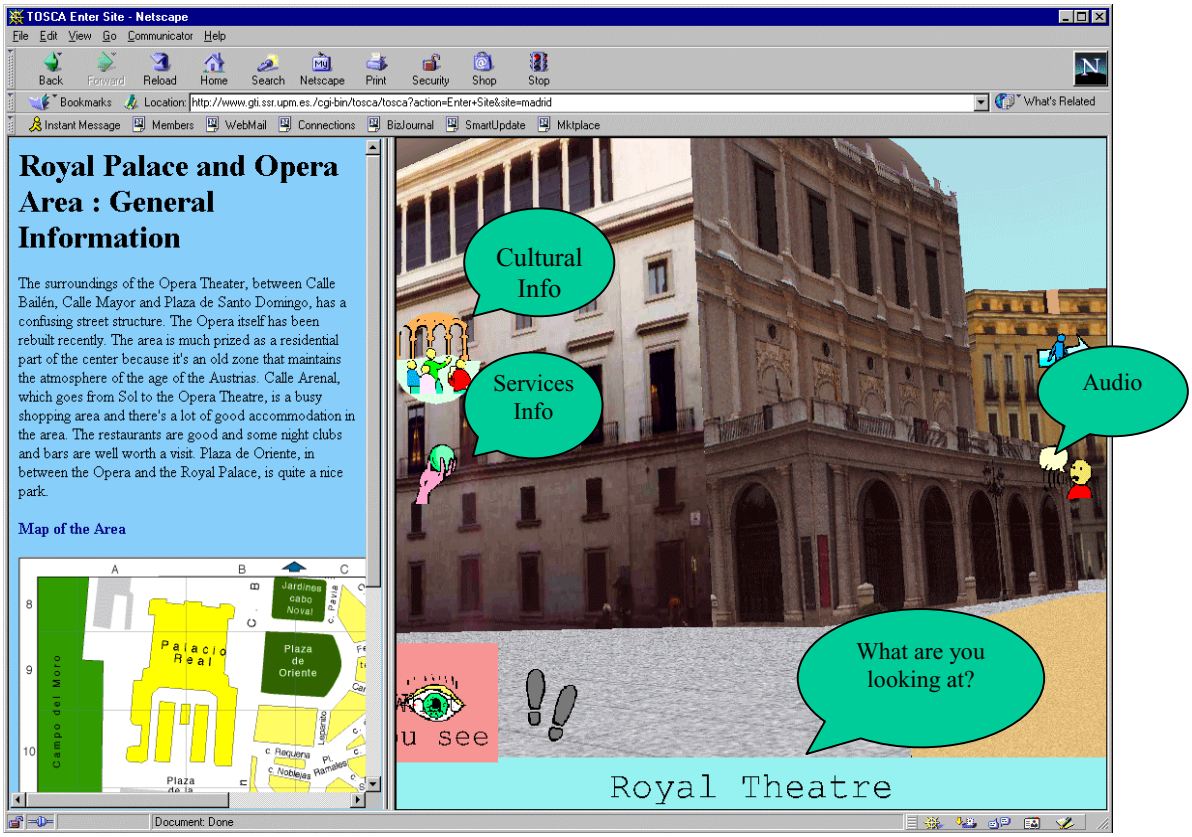


Figure 5: Information offered to the user when approaches a relevant object.

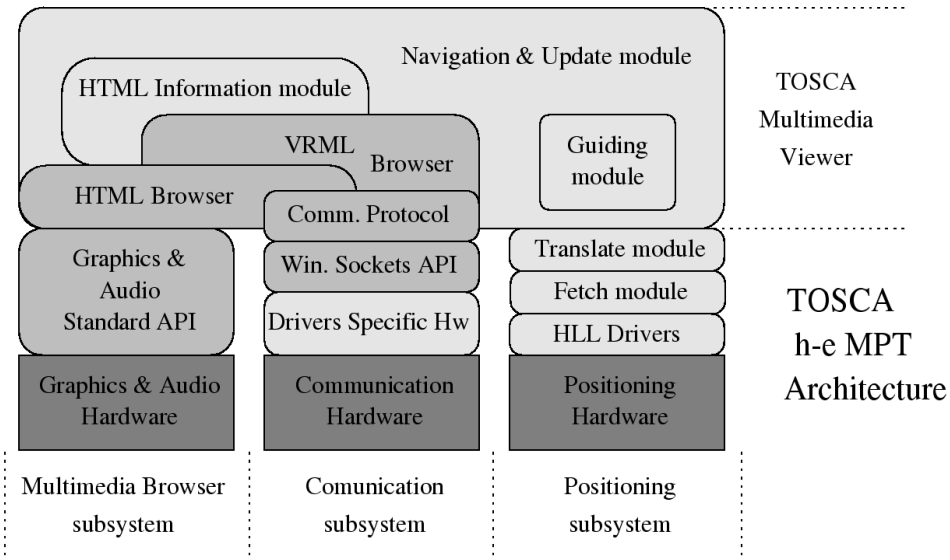


Figure 6: TOSCA High-End MPT Client architecture.

4.1.1 Positioning subsystem

One of the main characteristics of the TOSCA h-e System is the capability to automatically determine the information to be presented to the user according to his current position within the site. This subsystem is in charge of determining the current position of the user (tourist) in a suitable way to be associated to cultural information of the site loaded in the TOSCA Database.

4.1.2 Multimedia Browser subsystem

According to the position obtained from the previous subsystem the Multimedia Browser is in charge of handling the appropriate information requests to the IS to retrieve the information associated to the site. The nature of this information will depend on the characteristics of the Client, i.e. the type of information it can handle.

4.2 Information Server Architecture

Figure **7** presents a block diagram focused on the architectural components of the TOSCA Information Server. It is composed by three subsystems, each one divided into different functional modules: *WWW Server* subsystem, *Virtual Scenario Server* subsystem and the *TOSCA Database* subsystem.

4.2.1 WWW Server subsystem

The requests coming from the h-e MPT Client are attended by this subsystem. It consists of a conventional Web Server that either solves a request itself or forwards it to the Virtual Scenario Server for the generation of HTML and VRML documents.

4.2.2 Virtual Scenario Server subsystem

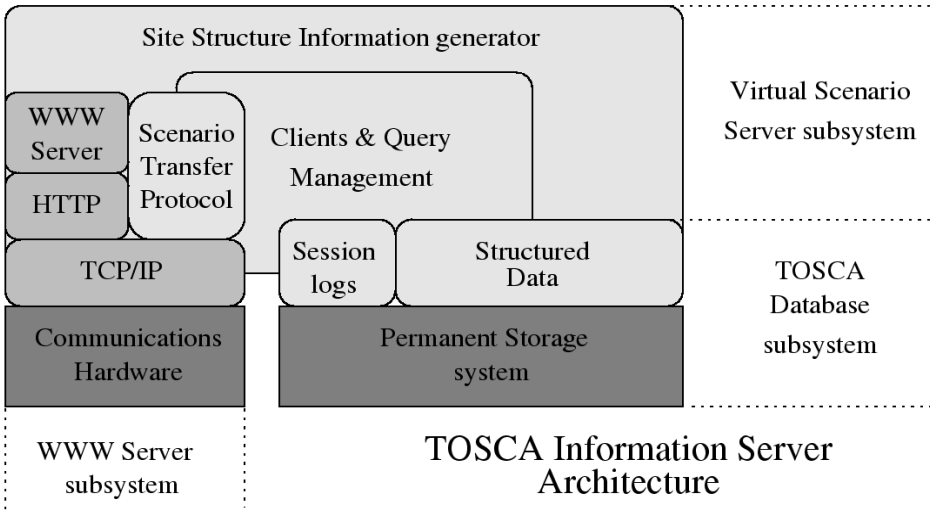


Figure 7: TOSCA Information Server Architecture.

The required developments within this subsystem lead to three different functional modules: the Navigation & Update, the HTML Information and the Guiding module. These three modules constitute the core of the Client developments. They form the so-called TOSCA Multimedia Viewer. While the first two manage the requests to the Information Server, the third one offers a simulation of the Positioning subsystem, needed when Guided-Tours (not controlled by the user real position) are implemented.

4.1.3 Communication subsystem

This subsystem carries out all the communications with the TOSCA Information Server. Using network support, they are handled through the Browsers, using the standard HTTP communication protocol.

This subsystem provides information of the site according to the h-e MPT Client requests. Queries to the TOSCA Database subsystem are built based on the Client requests. The information sent back to the Client is globally identified as Site Structure Information.

The Site Structure Information is conformed by two different parts: the organisation of the information in the database (association of information to relevant site elements like buildings, streets, gardens, etc) and, properly, the different types of information (i.e. images, text, web pages, audio clips, panoramic images or VRML models). While the data related to the organisation of the information is transferred for all the prototypes during the start-up phase, the particular information associated to the current position of the user will depend on the h-e MPT Client prototype capabilities.

Functionally, this subsystem is conformed by two modules: the Clients & Query Management and the Site Structure Information Generator module. The h-e MPT Client sessions (or connections) to the TOSCA Information Server are handled by the Clients & Query Management module. It builds the initialisation query to the TOSCA database subsystem based on the h-e MPT Client prototype capabilities. The result of this query is the Site Information (mainly structural) which allows the Client to find the correspondence between the user location and the pointers to the relevant information in the database. Besides, this module handles all the requests from audio clips or images (either simple or panoramic) according to the user position within the site.

Upon the information obtained from the TOSCA Database subsystem, the Site Structure Information Generator module builds the information that registers the organisation of the site. For the prototype including graphic models (VRML 3D Model [6] models or alternative structural representations out of the results of its queries to the database.

This information is organised in a convenient way for the special needs of the TOSCA applications. The structure is presented in Figure 8. Information is hierarchically organised and it goes from site dependant general information down to particular objects associated information. In Figure 8, there is the following general information for SITE 1:

- Cultural and Services Information (shortened as CI and SI). They are mainly links to text or HTML based information covering cultural or services associated to the site globally considered.
- Area Matrix. It is information that allows the system to find the correspondence between the position of the user within the site and the available information.
- Guided Tours. This information allows the Guided-Tour mode to operate. Several pre-defined tours may be available for the same site (GT-1, GT-N in the Figure). Each one is composed by a set of *Paths*, which link the different stops that form each Guided-Tour.

Set of objects that compose the site. Each object (i.e. street, building, square, fountain ...) has a unique identifier which is related with the identifiers included in the Area Matrix, and it may

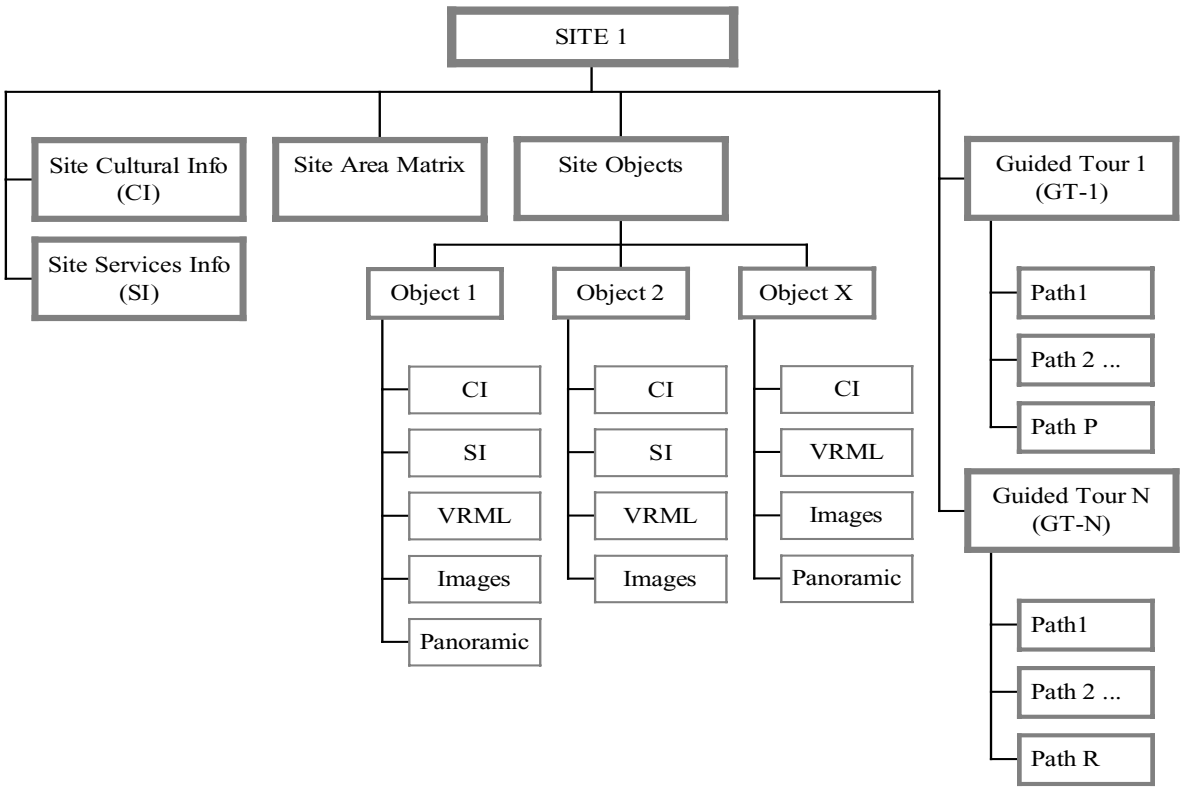


Figure 8. Organisation of the Information in the TOSCA Database.

[4]), all this information is directly handled through the WWW Server based on CGI technology (http). On the other hand, for the other prototypes, this information is transmitted using proprietary C developments directly using the TCP/IP [1].

4.2.3 TOSCA Database subsystem

This subsystem provides multi-user access to tourist information related to a tourist site. The Database is accessed through the Virtual Scenario Server subsystem, which builds the VRML

have associated: Cultural and Services information (as links), Images (mainly for prototypes not including graphics), Panoramic views and 3D VRML models. Some types of information do really point out to complex data structures that hold the parameters to handle extended functionality (for example, navigation within the Panoramic views).

5 CONCLUSIONS

An integrated architecture for Tourist Orientation has been presented Several innovative aspects are considered:

- The system, uses the information about the user location and orientation to query a database about tourist information related to the place where the user is or where h/she is looking at, and spontaneously shows that information.
- A hierarchy of available functionality is implemented via an integrated framework where a unique Information Server handles queries from different types of terminals (prototypes) with different hardware requirements and cost.
- The type and nature of the information supported ranges from simple audio guiding to Internet access via Virtual Reality environments.
- The system is configurable depending on the user profile, the terminal capabilities and the type of services provided.
- Two types of navigation (tour modes) are offered: the classic Guided-Tour in which the tourist follows predefined paths in the site and the new Automated-Tour, based on the positioning hardware. This mode lets the user move freely in the site showing context/location dependant information.
- The system can operate in-site and off-site depending on the specific purpose of the real or virtual visit to the site.

The presented implementation of the system, corresponds to one of the main outcomes of the **TOSCA** project. This software helped demonstrating the fulfilment of the system expected functionalities, although as a first step, it was developed up to a software pre-prototype. Current work focus into different relevant aspects related to the system fine tuning and very particularly to technology update: XML is deeply introduced in the application adding flexibility to the site description and object manipulation, together with Java developments dealing with large site virtual reconstructions intelligent manipulation.

Future work will be focused in extending the available set of services (very particularly to extend them to indoor environments such as museums or galleries) and types of information, providing full scalability in the size of the site database and number of terminals. State of the art technology will be investigated for providing facilities such as automatic ticketing or advertising in the terminals.

6 REFERENCES

[1] D. E. Comer and D. L. Stevens. Internetworking with TCP/IP. Prentice Hall International Ed.1993. ISBN 0-13-470154-2

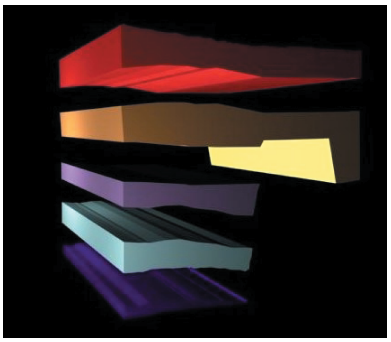
[2] G. Ennis and M. Lindsay, VRML Possibilities: The Evolution of the Glasgow Model. IEEE Multimedia, pages 48-51, June-July 2000. ISSN 1070-986X.

[3] J. Gosling, B. Joy and G. Steele. The Java Language Specification. Add. Wesley, Reading Massachusetts 1996. ISBN 0-20-163451-1

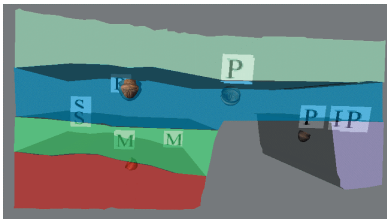
[4] J. Hartman and J. Wernecke, The VRML 2.0 Handbook. Silicon Graphics Inc. 1996. ISBN 0-201-47944-3

[5] HTML 3.2 Reference Specification. http://www.w3.org/TR/REC-html32.html

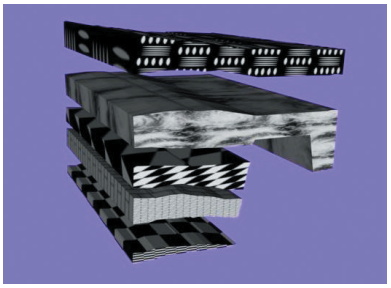
[6] ISO/IEC-14772-1. VRML 2.0 Standard. 1997.



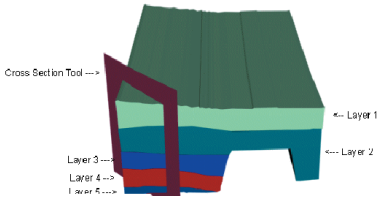
An Exploded View of a Sector of Stratigraphy.



Strata being shown with embedded artefacts in the stratigraphy tool.

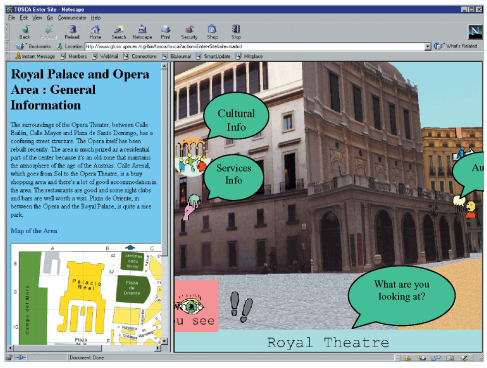


Layers of Stratigraphy are Represented by Different Styles of Hatching.



Creating a X-section View.

Green, Cosmas, Itagaki, Waelkens, Degeest, Grabczewski: **A REAL TIME 3D STRATIGRAPHIC VISUAL SIMULATION SYSTEM FOR ARCHAEOLOGICAL ANALYSIS AND HYPOTHESIS TESTING,** pp. 271-278.



Information offered to the user when approaches a relevant object.

Salgado, Rendón, Artola: **System Architecture for Tourist Orientation: The TOSCA High-End System,** pp. 285-294.