E-MUSEUM - A CONTENT MANAGEMENT SYSTEM FOR PROVIDING MUSEUM VISITORS WITH PERSONALIZED AUDIOVISUAL INFORMATION

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Abstract – In this paper we present *E-Museum* a system for providing advanced audiovisual guidance services in museums (and exhibitions) to different classes of users. These services include, *automatic* and *on demand* audiovisual content retrieval, both on-site and through the Web. On-site services are provided through handheld devices, which exploit the user's contextual state, mainly defined as visitor location and organization of exhibits. The main distinguishing characteristic of the system is that it is built as an open, modular platform comprising a core of reusable components and interfaces for supporting different types of services and devices.

1. INTRODUCTION

The term *electronic-museum* may include different concepts, and corresponding technologies, ranging from in museum content presentation (e.g. by exploiting virtual reality and immersion technologies, or through context aware mechanisms and handheld devices), to content publishing through the museum's web site. In both cases, simple interfaces for content searching and retrieval should be provided without disrupting the user from focusing on the exhibits themselves. Especially in the first of the above cases, any platfom arrangements (e.g. cables, servers, receivers) should not also distort the physiognomy of the museum..

Museum visitors can be classified to different levels, first of all, according to their interests and background, ranging from children and regular visitors, to professionals and researchers. Each of them demands a different level of knowledge and detail. Furthermore, users can be classified accroding to the terminal device they posses. For example, laptop users may be able to get full versions of the content (e.g. 3D models, detailed maps), while small devices (e.g smart phones or Personal Digital Assistants) users may be able to acquire a limited version of the content on-site, but they may ask for an enhanced version for off line usage (e.g. stored in a CD).

Regarding on-site guidance systems, advances in the field of Location Based Services (LBS) are exploited. Many attempts have appeared in the area of location based content retrieval systems, in various application fields, especially after technologies

such as GPS became widespread. One such is presented in [1], in which advanced wireless services are provided in the Athems International Airport. Also, in [2], AVATON, an ambient information system allowing location-based, interactive guidance inside the area of the Aegean Volcanic Arc is presented. In AVATON, a guidance session includes complex content retrieval composed of geographical, historical and geological information and can be realized both on-site through handheld devices, and through the Internet and TV channels. Recently, a lot of museum and exhibition guidance systems which use location-based techniques for providing personalized content have appeared worldwide. These systems are either commercial or research prototypes and many of them have been included in EU funded projects, such as CRUMPET (CReation of User-friendly Mobile services PErsonalized for Tourism) [9] or PEACH (Personal Experience with Active Cultural Heritage) [10]. Another European attempt to provide a set of tools capable of authoring personalized museum content for different guidance purposes and different users has appeared within the scope of the IST SCALEX project [15]. SCALEX system attempts to define a core implementing the concept of e-guidance. Based on this and on the definition of generic interfaces, different services will be able to be defined and attached, in order to ensure extensibility.

It is worth mentioning that a big number of the existing applications are particularly intended to enhance the experience of a visitor in different museums. The common characteristic of all these systems is the use of PDAs as the basic mobile interaction device. Such representative systems are 'ImogI'[11] and 'Points of Departure'[12]. The indoor "ImogI" system is located in the Gallo-Roman Museum of Tongeren, uses Bluetooth to establish communication between the PDAs and the exhibits, and reflects the closest exhibits to the location of the user, while 'Points of Departure' system, in San Francisco Museum of Modern Art, gives details, in video and audio form, about the techniques used in an artwork, the message that the artist wants to demonstrate etc., by having 'thumbnails' of several exhibits on the PDA's screen. A more detailed discussion for all these relative architectures can be found in [13], and [14].

Despite the fact that electronic guidance inside museums is becoming a highly competitive sector, which is also of high technological interest, relevant integrated systems, for both on site and on WWW guidance are not yet either widespread or standardized, and when it is provided it is often based on proprietary and installation-specific solutions. Through the E-Museum project, which is presented in this paper, we envisage to provide a core of reusable components capable of supporting advanced museum (and exhibition) services, not only to visitors in the museum, but also to virtual visitors who access collections through the web. Among the most important features of those components are *automatic context-aware and on-demand content retrieval on-site* (that means in the area of the museum, which can be indoors or outdoors), and *content access through the web.* In both cases, semantic web extensions enabling high-level quering and semantic interconnection with external resources (e.g. other similar collections) are examined. Furthermore, flexible mechanisms, for adapting to most museums needs are present, in regard to the physical platform, computing and communication resources, to the site configuration and set up and to the user equipment.

The rest of the paper is organized as follows: Section 2 describes the services and the technical requirements that the E-Museum system will support, Section 3 illustrates the overall system architecture employed, while in Section 4 conclusions are drawn and the future work is specified.

2. E-MUSEUM SERVICES AND TECHNICAL REQUIREMENTS

E-museum envisages to support a wide range of services, targeting at different user profiles and terminal devices. The most important services that will be provided in the scope of this project are the following.

1. *Automatic (push) content retrieval based on visitor proximity to an exhibit or group of exhibits:* The handheld device that the user carries identifies his/her location in relation with a certain exhibit or group of exhibits, through a suitable positioning technology. After location identification, a request for relevant content is created, which can be either audiovisual content related with a certain exhibit (or group of exhibits), or directional information (e.g. vector maps) indicating to the user how he/she can move throughout the museum.
2. *On demand (pull) content retrieval:* This service is enabled via the E-Museum wireless communication infrastructure, and it addresses more experienced users. Context aware information, related with the user's position, is used to help her/him to browse the E-Museum's collections and/or to create more targeted search queries.
3. *Creation of live linear guidances:* User provides his/her profile and preferences (e.g. concerning a certain historical period that wants to examine) and the system automatically creates linear guidances including only the exhibits of interest and excluding exhibits that are not of interest to the user. Guidance and location information is also provided in this service.
4. *Registration of path and content of interest for offline usage:* Users with handheld devices may be able to get only a small subset of the content while on-site, due to limitations in the processing power of their devices. However, the path with exhibits of interest is registered and presentations with full versions of content are created for offline usage (e.g. stored in CDs that the user buys after the visit to the museum).
5. *Content publishing to the web:* Museum content distribution is not only possible on-site, but is also published to the Internet. High-level search interfaces are provided, which can also be implemented with the use of semantic web technologies. Interconnection with other museum collections and web sites of interest is also possible.
6. *System management and update of the content base:* Content must be easily updated and enriched by the stuff of the museum through simple user interfaces with the content management system.
7. *Peer-to-peer / Ad hoc content exhange among visitors:* In this case, guided tour scenarios can be supported, in which a central guide retrieves content and distributs it to a group of visitors who passively monitor the session. Also, games for groups of children visitors can be supported.

8. *Electronic guest book:* Users can insert their own comments concerning museum services, and they can retrieve comments inserted by other users as well.

The above basic service scenarios can be further combined to produce more hybrid guidance scenarios. In order to support the aforementioned services, a certain hardware and software architecture is required and specific system characteristics are desirable. Thus, the architecture, proposed, that will be elaborated in the next paragraph, imposes that certain requirements should be fulfilled. These, based on an initial qualitative analysis are the following:

1. *High system modularity*. The various system components, (presentation, content management, database, multi-device interfaces, etc.) will be designed and implemented in a modular manner in order to select the appropriate components in each specific installation.
2. *Support of different users.* Extensive support for different users will be built in the system. Various actors (e.g. administrators, museum experts, content authors, visitors, children, researchers, etc.) will be identified and appropriate functions will be implemented.
3. *Support of different devices:* the system should be able to support PC-based terminals, in museum booths as "virtual visitors" equipment, but also mobile devices. While PDA devices are supported by most of the current systems, the platform presented here will also support a variety of smart phones. Smart phones are steadily adopted as generic computing and communication devices for edutainment applications.
4. *Support of different communications and localization technologies.* The platform should be independent of the underlying hardware infrastructure. Thus the system will support a variety of communication means for the on-site terminals (e.g GPRS/3G, WLAN, Bluetooth) but will also support a variety of localization techniques (e.g. GPS/Bluetooth, IrDA or RFID in the future).
5. *Use of open source and open standard solutions.* In order not only to avoid system lock-in, but also to reduce development costs the system will be based on open standards and open source components, where possible. Furthermore, independence from the underlying hardware and software platform, by selecting generic widespread approaches, will be provided.
6. *Interfaces with semantic web infrastructure*. While the Semantic Web is in its infancy the system's content management component will be designed with semantic web hooks, in the form of proper metadata management functions and web services interfaces, in order to interoperate in the future with Semantic Web systems.

Based on the above partial system requirements the platform will be able to meet its core functional requirements, which are to provide *independence over various technology solutions and site configurations* and *non-intrusive system installation.* The system is flexible enough in order to be adapted to match the characteristics of the specific museum installation, in terms of hardware, software, communication, localization and exhibition needs.

3. E-MUSEUM ARCHITECTURE

3.1 Overview

In order to provide the aforementioned services and tackle the relevant technical requirements the system will be implemented around a set of core reusable functional components. The main reusable components reside to the backend server side and the end user terminals. However, the required communication infrastructure and the terminals themselves are also necessary system elements. In greater detail, the platform will comprise the content management server, coupled with the e-museum's frontend web server. Connectivity to both the public Internet and the e-museum users will be provided by a wireless communication infrastructure, while the end-users will access point of interest specific content through their selected devices. This general system overview is depicted in Figure 1, while a more detailed design level description of the system's components follows.

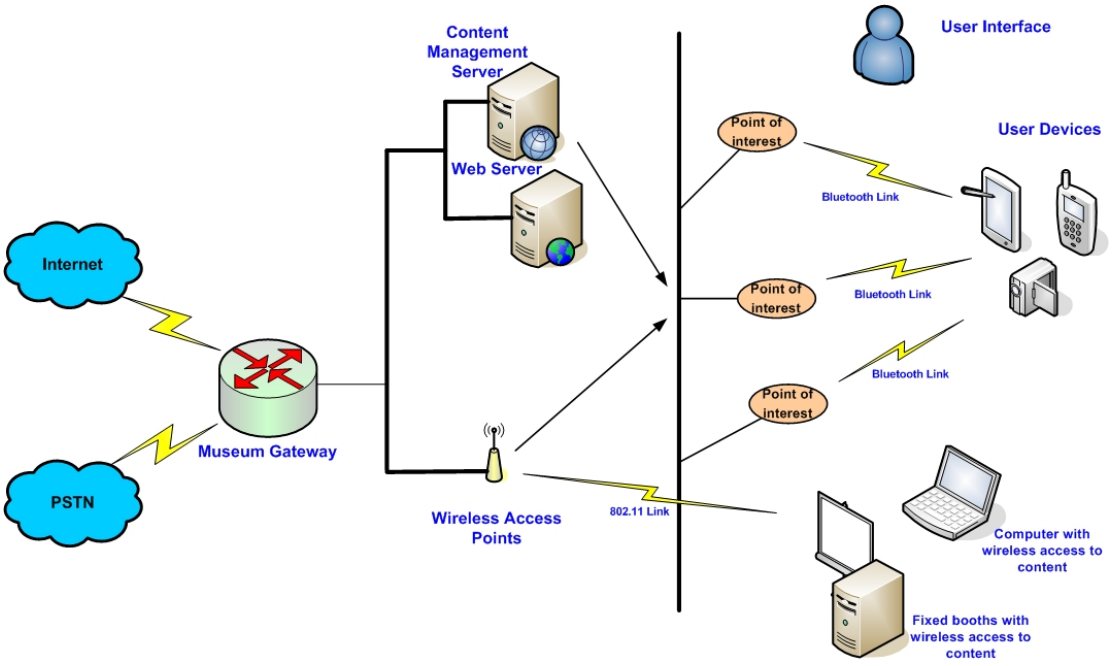

Figure 1 E-museum system overview

Communication infrastructure

It is envisaged that the museum can be connected to the public Internet. In order to provide services to the museum visitors an appropriate wireless network is required, nevertheless, the e-museum platform is designed to be orthogonal to the actual network type choice, as long as if offers IP level connectivity. The wireless network, depending on museum requirements and needs, can be based on the family of WLAN, WiMAX or Bluetooth standards. For some of these networks, their communication infrastructure can be also exploited as a mean for providing coarse-grained localization functions. Each of these alternatives poses different characteristics to bandwidth coverage and installation expenses.

Backend platform components

In the backend platform, the content management and the museum's front-end web server are deployed. The first is responsible for managing museum related textual content which is stored in the museum database. Each entry is associated with other entries and possibly with a specific point of interest (e.g. exhibit or group of exhibits). An appropriate software module for providing association between location information given by the user terminal and a specific point of interest is implemented. This association can be performed independently of the localization mechanism selected. Audiovisual content is stored to an audiovisual content repository and a streaming server. The platform can use a variety of audiovisual streaming formats, appropriate for both PC based platforms and mobile devices, such as smart phones. Every time user location is associated with a point of interest, the content related to this point of interest becomes automatically available by the content management system, through the wireless network. Association of users to points of interest is performed automatically, through the localization mechanism available (push mode), or semi-automatically through user selection (pull mode),

End-Users terminals and localization mechanism

In order to provide high flexibility and adaptability to each museum needs, a variety of end-user terminals are included as possible terminals in the platform. These include handheld devices (PDAs and smart phones) or laptops to gain access to all the services that e-museum platform will provide. In addition, there can be some fixed booths for common use, where each visitor has the ability to explore the content for all the points of interest. Terminals are both the end-user interface and the means where localization mechanisms reside. User interfaces are based on Web based solutions, and the content retrieval is driven by the terminal location. Location determination is a distributed process which involves both communication with the relevant server component, and with some terminal resided software. As a whole, the location identification software component tackles the interface of various localization mechanisms (e.g. GPS, Bluetooth, IrDA, RFID, etc) to the terminal and the communication with the server. There, the terminal provided location reference is translated to a point of interest which is communicated back to the terminal in order to drive the location specific content retrieval.

3.2 Description of specific system components

After having illustrated the overall system-level approach, in this subsection a more detailed description of the most important system components is given. These are the ones that provide the system's core functionality independently of the specific communication infrastructure, the end user terminals and the localization method selected: the *server side components*, including the content organization, the front end components and the semantic web extensions, and the *end-user terminal* software for location specific content retrieval.

Server-side components

Content organization and management

Text based content is stored in a relational database, while audiovisual content resides in a high performance external repository, providing metadata based search support and distributed storage functions. In parallel with the content, appropriate metadata is stored. Metadata formats, such as the Dublin core are supported, but also other custom extensions can be also used. However, it is a design decision not to provide a specific metadata set, but instead provide the tools for the museum to specify and/or select its preferred metadata set. This makes the system open to transition to forthcoming or future metadata sets but it also enables support of older proprietary formats. Our intention is to provide tools for organizing the appropriate metadata set while not being tied to a specific standard.

Content management functions will be built based on an existing content management system, as well as on e-museum specific extensions. The open source Joomla CMS has been selected. Its modular and extendable architecture serves as a basis for further development. Functions such as content classification, different user hierarchies and wide support of multilingual content are supported. Furthermore, a number of functions, such as a guestbook, billing systems, email based notifications, etc. can be built using preexisting Joomla components. User management and related content management functions include features such as an extensive user role hierarchy, which extends up to six levels: administrator, manager, author, registered and guest users, content management roles according to users, interactive features such as dynamic polls, guestbooks and page statistics, these can provide important feedback to the system managers. Moreover, using RSS 1.0[1] we offer the required syndication among museums and end-users.

Front-end components

The front end components of the system are providing Web-based user interfaces, as well as the audiovisual streaming features. In order to cope with the needs of different targeted user devices, (PDAs, smart phones, PC based terminals) and user requirements, content is presented using different approaches for each device and user. Thus, appropriate presentation templates and content retrieval paths are provided in parallel with mechanisms for adjusting content to different user profiles and devices. Audiovisual content will be presented through an appropriate streaming engine to the users terminals, exploiting the relevant IETF/IP based protocol stack. Furthermore, tools for offline content trans-coding for portable devices will be employed, where appropriate, in order to make content accessible to these devices.

Semantic Web extensions

The content management system is extended in order to offer semantic web ready functionality. The aim is to provide a path for combining conventional databases with ontologies developed specifically for museums. Ontology languages like OWL [3] or the prevalent RDF [4] are supporting this effort. We are going to extend the content sharing capabilities of the CMS into a semantic-oriented scope. New tables will be added to the database that will correspond semantic metadata to existing information

[1] RDF Site Summary

of the system. The system will be tested with various test level domain specific ontologies. However, a specific ontology, such as CIDOC, is not selected for metadata organization, but instead a generic mechanism for mapping the relational database to specific ontological descriptions, including the one of CIDOC, is provided. Relevant works are also presented in [5-7]. An appropriate module responsible for semantic web extensions will be developed. This, will impose queries to the aforementioned ontologies. The query language of choice is ARQ, an implementation of SPARQL, that was recently approved by the W3C working group[2]. The Jena [8] semantic web framework is the practical choice for manipulating ontologies on the lower level.

End user terminal software and localization mechanism

While the end user content access mechanism will be Web based, in order to associate the terminal with a point of interest, an appropriate terminal side software component should be provided. Furthermore, this software will support a variety of localization methods, in order to match to different system configurations, and it will provide an indication of the terminal type. The selected terminal platform, apart from PC and PDA, is smart phone based. The Symbian OS has been selected as a development platform since it provides wide user penetration and rich functionality. According to current global shipment statistics (e.g. 'Smartphone Summit 2005'), Symbian OS appears to be the most popular (preferred) OS for smart mobile devices and thus we decided to use any device that uses the particular system (in particular v9.1, which is the latest release). All the appropriate applications for the PDA and the smart phone are being developed with J2ME using MIDP profile (which supports packages as J2ME Web Services, Bluetooth API etc.).

The identification of a user's position in an indoor environment can be performed at various levels of granularity: e.g., one is the identification of the exact user position, where the system can identify the closest exhibit; another level is when the system is only able to identify the room where the user is located.
To explicitly localize the users in the museum, the considered technologies considered are:

- WLAN
- Bluetooth
- IrDA

In our platform, the position of the the mobile device can be mainly determined by the use of Bluetooth and/or GPS technology. The 'communication' between the PDA and the artwork is quite simple in such a scenario; a 'Bluetooth UUID' in the server represents each exhibit or a group of exhibits. Thus, once the user approaches the exhibit, he/she, almost instantly, receives a message on the PDA screen (in the form of text or thumbnails) informing him about the available nearby exhibits.

As far as it concerns the alternative positioning systems, the use of RFID tags was not discussed as an implementation choice, as experience from relative projects has shown some drawbacks [16], focusing, especially, on the restriction to short-range communication and other issues [17]. Additionally, the adoption of WLAN level

[2] http://www.w3.org/2001/sw/DataAccess/

mechanisms in order to localize users during their visit to a museum has, also, faced major problems. In this case, triangulating the signal strength from at least 3 Access Points, usually, reveals the location of the users with an approximation of 1m. In addition, a calibration step is always necessary before each implementation. With the use of IrDA - and despite its popularity - problems also exist. Use of many IrDA beacons may be prohibitive, since they are more expensive and there can be mixing signals, if they are placed next to each another. However, hooks for adding a variety of localization mechanisms, including the ones aforementioned are included.

4. CONCLUSIONS & FURTHER WORK

In this paper work in progress aiming at providing a system for audiovisual guidance services in museums (and exhibitions) to different classes of users is presented. The system provides automatic and on demand audiovisual content retrieval, both on-site and through the Web. The intention is to design the system as an open, modular platform comprising a core of reusable components and interfaces for supporting different types of services and devices. Since the presented work is still in progress the system architecture and the most important components were introduced. The future work, among others, includes the implementation of the components presented, this task is currently underway with different degrees of completion, but also collecting early feedback from potential users in order to refine the system offered services.

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