Intelligent Mobile Recommendations for Exhibitions Using *Indoor* Location Services

Mersini Paschou, Evangelos Sakkopoulos, Athanasios Tsakalidis, Giannis Tzimas and Emmanouil Viennas

Abstract Information and Communication Technologies (ICTs) are utilized in an increasing number of museums and collection exhibitions world-wide. In this chapter, we present novel fully-automatic mobile assistant with indoor recommendation services. We will discuss novel efficient techniques in order to provide within a single software solution (a) typical, (b) semi automatic and (c) seamless-no human interaction tour guidance and recommendations during an exhibition tour. We have designed, developed, deployed and evaluated the solution at a real case exhibition to provide at a users' level an intelligent personalized virtual guide. The provided solution aims to assist visitors and to provide full automatic multimedia or audio guidance during exhibition visits using Wi-Fi based indoor and outdoor positioning, mobile messaging and wireless data provisioning. In the proposed chapter we will discuss the design, implementation, deployment and outcomes of the research and development endeavor for the integration of mobile multimedia, positioning and messaging services into a novel automatic personalized exhibition recommender-assistant. Deployment and evaluation issues of the proposed solution will be discussed for the case of the Museum "Digital

M. Paschou · E. Sakkopoulos (✉) · A. Tsakalidis · E. Viennas
Department of Computer Engineering and Informatics School of Engineering, University of Patras, Rio Campus 26500 Patras, Greece
e-mail: sakkopul@ceid.upatras.gr

M. Paschou
e-mail: paschou@ceid.upatras.gr

A. Tsakalidis
e-mail: tsak@ceid.upatras.gr

E. Viennas
e-mail: biennas@ceid.upatras.gr

G. Tzimas
Department of Applied Informatics in Management and Finance, Technological Institution of Messolonghi, Nea Ktiria 30200 Messolonghi, Greece
e-mail: tzimas@ceid.upatras.gr

G. A. Tsihrintzis et al. (eds.), *Multimedia Services in Intelligent Environments*, Smart Innovation, Systems and Technologies 25, DOI: 10.1007/978-3-319-00375-7_3,

Exhibition of History of Olympic Games in Antiquity" in Ancient Olympia (Greece, EU).

1 Introduction and Motivation

Multimedia application use electronic information that may integrate different types of objects including text, images, video and audio. Information and Communication Technologies (ICTs) used in appropriate ways in a museum or an exhibition can result in a functional upgrade of the visitor's experience [1]. The added value includes promotion and enhancement of educational, research or entertainment purposes. In the past few years personalized services [2] of Information technology have begun to be adopted in a rapidly increasing number of cultural and touristic exhibitions around the world [3–6]. The aim of these services is to provide an additional and perhaps more interesting dimension to the presentation of the exhibits and ultimately attract more visitors [7, 8].

In fact Smartphone application marketplaces and stores include a number of apps that serve as a substitute of a typical travel guide. Unfortunately, such applications are not possible to support automatic recommendation and guidance whilst indoors due to lack of GPS signal. There are semi-automatic attempts to provide guidance using external aids such as numbered signs, QR codes or RFID signs. However, all the former approaches involve either architectural interventions at the exhibition halls (e.g. adding labels and posts which may spoil exhibits presentation etc.) or human interaction and explicit user choices in order to provide recommendations and further assistance. In our approach we propose a novel smartphone app solution to serve as a recommender personalized museum guide. To deliver the recommendation a novel indoor position solution based on Wi-Fi technology has been employed. The automatic recommendation system delivers accurately exhibits presentations and multimedia details detecting the position of the visitor in the museum with less than 1 m accuracy. The proposed solution has been deployed and working in the Museum "Digital Exhibition of History of Olympic Games in Antiquity" in Ancient Olympia (Greece, EU).

In our case study and implementation environment of the proposed mobile recommendation museum assistant, the guests of the Digital Exhibition of History of Olympic Games are invited to learn about the Games and the Greek culture through interactive media. These interactive modules include interactive discussion tables and applications that visitors are able to interact with, by touching the monitor. Additionally, a timeline system is available, which consists of a vertically mounted display, and can be moved along the horizontal axis by the visitor. Various dates related to the celebration of the ancient Olympic Games are carved on the wall behind the screen. Dynamic multimedia information is presented, depending on theme chosen and the date corresponding to a specific screen position. A researcher information station is provided, whose purpose is to enable specialized visitors (i.e. archaeologists, researchers and students) to explore in

depth the history of the area and the exhibits and allow them to print anything they consider interesting.

The main objective is to render a visit to the Museum an experience that visitors will remember with pleasure, by providing high quality services. Therefore, a set of special services and facilities are provided that are divided chronologically into three categories: “Before the visit”, “During the visit” and “After the visit”. As a result visitor management is facilitated and the overall experience of the visitor is improved. The visitor has a number of digital media available, which is the key to a smooth transition from the Archaeological Exhibition itself to the Digital Gallery and aims at attracting visitors to the main Digital Gallery. The proposed mobile museum guide assists the visitor with automatic guidance or typical step by step semi-automatic assistance and recommendations throughout his/her visit.

Details on the mobile assistant are discussed as follows: Sect. 2 provides an overview of related work. Section 3 lays down the outline of the storyboard designed to depict the application logic. In Sect. 4 the architecture of the system is discussed. Section 5 presents indoor positioning and technologies. Finally, the case study functionality and evaluation of results are discussed in Sect. 6. Section 7 concludes the chapter and provides future ideas for further investigation.

2 Related Experience

Multimedia tools used in museums facilitate communication of large amounts of information in a user-friendly and interesting manner. In parallel, multimedia tools allow visitors to access the information they require at their own pace [3]. Recently, many researches and approaches to analyze personal behavioural data and applications which use these logs are reported [9, 10]. Thanks to downsized and high-performance device such as smart phone, recording people’s life becomes easier. Besides, by mining these data, we can receive useful feedbacks. Wi-Fi based indoor location systems have been shown to be both cost-effective and accurate, since they can attain meter-level positioning accuracy by using existing Wi-Fi infrastructure. However, those systems still introduce technical challenges that have to be faced and it turns out that creating a useful indoor navigation app requires more than navigation [5].

A sensor-assisted adaptation method is proposed in [4], which employs RFID sensors and environment sensors to adapt the location systems automatically to the changing environmental dynamics. The proposed adaptation method performs online calibration to build multiple context aware radio maps under various environmental conditions. An image-based indoor positioning system for digital museum application is presented in [11], using images to which location information is embedded. By using robust image matching, fast nearest neighbour search algorithm based Locality Sensitive Hashing (LSH), and the confidence measure which takes into consideration of the location of the objects in the query image, the presented system aims at estimating users’ locations with high accuracy and in a short time, which is supported by conducted experiments.

3 Design and Storyboard

The key aim of technology in the premises of a museum is multiple, offering new dimensions in the experience of the visitors. In this chapter research and development results are presented as the outcome of the endeavor for the delivery of the Museum "Digital Exhibition of History of Olympic Games in Antiquity" in Ancient Olympia (Greece, EU). The novel mobile solutions implemented in this case have a triple target:

- Visitor participation in collective activities, through the implementation of digital assistants that encourage collective actions (e.g. mobile messaging, family member/friend position detection).
- Election of the "games" as a social commodity and a basic ingredient of the ancient Greek life-style, the perpetual contrast of the opposites, the personal freedom and the competitive spirit.
- Unobtrusive integration of all digital means with the available ancient exhibits within the museum.

Among the numerous different digital solutions delivered in the museum, the most important role plays the Automatic Personalized Tour with mobile devices (PDA, smartphones), which every visitor receives upon his/her entrance in the museum. It is based upon a modular architecture that ensures the separation of concerns maximizes re-usability of sub-systems and delivers fine-tuned positioning, messaging and personalized multimedia presentation services.

In this chapter the architecture of the Automatic Personalized Tour with mobile devices solution is discussed and its high level functionality in the area of the museum. A discussion of the necessary subsystems, the storyboard, technological hints and the final outcome will be outlined to show the feasibility and effectiveness of the proposed approach. The overview of the functional specifications is outlined below.

(a) A visitor receives essentially a portable device (smartphones) properly customized. The handling should be simple and done by touch screen. He is given the possibility for presentation of multimedia data in one of at least four languages available. It is possible to choose among different tours such as a short content tour or a fully detailed tour.
(b) The automatic personalized assistant has a novel system for identifying and presenting the position/location of each visitor in the wide area of the museum. The positioning is based on two interconnected wireless Wi-Fi 802.11 g network infrastructures; (1) one within the 14 exhibition halls and (2) a second outside and around the museum. Contrary to previous approaches, the solution is designed and implemented from scratch in order to achieve minimum error location detections, minimum network bandwidth consumption and number of handshakes as well as minimizing PDA performance cost. This way, the visitor can wander on the premises of the museum freely wearing the mobile device and the headphones and depending on the visitor's current position, the

equivalents audiovisual multimedia data is presented to him/her. Moreover, the visitor has information on the position of his family and/or his friends in the museum as the tour assistant has the possibility of establishing a group of tour members move independently if they wish.

(c) Alternatively, the assistant smartphone tour app can operate non-automatically allowing the user to choose directly the multimedia presentation that wants to watch and listen to independently of his/her position in the museum.

(d) In addition, the tour assistant supports mobiles instant messages between visitors in the same group of users. Also allow each user to receive information messages from the museum information desk through a specially designed Monitoring and Management Visitors Administration Console.

Another key advantage of the proposed approach is that each subsystem is supported by an XML based layer that allows (a) clear separation of concerns and (b) maximizes the chances of re-usability of the sub-modules (e.g. mobile positioning, multimedia data provisioning, messaging, user profile and logging). The fundamental non functional specification is the XML based data interchange at all layers of the solution, based on the idea of multi-layered profiles of [6]. The content and customization of the mobile application and services are all XML based in order to achieve maximum scalability and interoperability. Personalization is also achieved through XML based user profiles and visitor's choices XML storage. XML support is also the basis of the messaging approach in order to enable extensions and allow interconnection with messaging servers outside of the museum if needed.

The application is designed to help navigate each visitor within the museum. The museum is physically divided in 14 exhibition halls and thematically divided into 12 thematic sections. Each section has from 1 up to 4 thematic keys. The solution is possible to handle multimedia data for any number of halls and/or thematic rooms and keys of the data presented. The term "keys" includes extra information (it can be regarded as a sub-unit) that are available to the visitor after watching the content on a specific section chosen. So if there are 2, he/she keys will be able to select and view two further sub-units related to this topic.

There are two main different types of operation for the application:

- Automatic operation (automatic positioning of the user current position inside the museum using the Wi-Fi network).
- Manual operation (the visitor choose manual the presentation of a thematic section which would like to attend).

There are three different ways of tour:

- Audio tour (contains only an audio presentation on the thematic sections).
- Detailed audio tour (contains only an audio presentation on the thematic sections and the keys).
- Audiovisual tour (contains an audiovisual presentation on the thematic sections and the keys).

Another observation is that our application is multi-language and more specifically supports the following languages: Greek (Gr), English (En), German (De), French (Fr). The XML underlying customization layer allows the integration of any number of additional languages. For the latest Olympic Games a prototype for the Chinese language has also been developed. A number of sub-cases are also included in the scenario to deal with exceptions and handle possible errors such as failure of Wi-Fi due to electrical shortcuts, malfunction of the PDA device that leads to automatic locking of the PDA and more.

4 Architectural Issues

Next the overall architecture of the portable devices system is presented and the building modules are analyzed below. The personalized assistant consists of and cooperates with the following components:

- Mobile Devices Subsystem at a Visitor level (MDSC): it constitutes the smartphone application that can be given installed at the mobile devices offered by the Museum or maybe downloaded through the local area wireless network.
- Mobile Devices Management and Disposal Subsystem (MDMDS): it includes management software for managing visitors, mobile devices docking station-carousel, preparation of MDSC during the charging and the updating of data in MDSC, as these are taken from the DMS subsystem and the operation/subsystem issuing data for portable devices.
- Networking Services Subsystem (NSS): it includes services and management functions of the MDSC subsystem such as location positioning, monitoring the location of visitors inside the museum, where WNIS and Communication Server is available.
- Data Management System (DMS): it includes the special operation of publication of multimedia data that is presented in MDSC subsystem.
- Wireless Network Infrastructure Subsystem (WNIS): it includes the necessary infrastructure for the availability of wireless interconnection of MDSC.

A first-level representation of the overall architecture of the subsystem together with the associated systems and subsystems with which it interacts shown in the figure below (Fig. 1), and then presented in more detail each module.

4.1 Mobile Devices Subsystem at Visitor Level

This subsystem is the basic application that will present the solution that will be installed on mobile devices. It consists of a Cell Application which includes the following three applications:

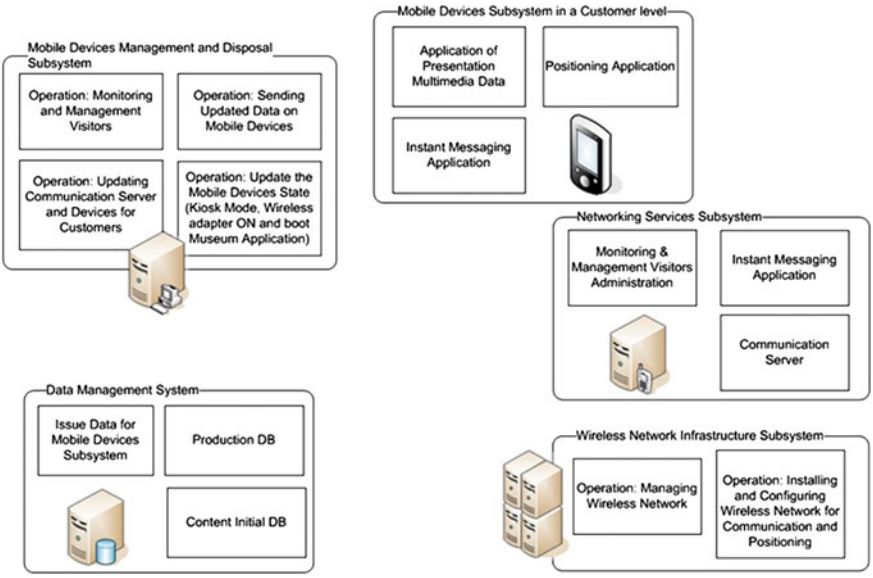

Fig. 1 Overall architecture of the system together with the associated systems and subsystems

- Application of Presentation Multimedia Data
- Instant Messaging Application
- Positioning Application.

The following are the general operating requirements of the subsystem, the way interfaces with other subsystems and analyzed in greater depth the applications that compose the particular subsystem.

4.1.1 Operational Specifications of Subsystem of Mobile Devices at Visitor Level

This subsystem (MDSC) is the backbone of Mobile Device Subsystem. The basic functional specifications are as follows:

- Presentation of multimedia data in four languages for content applications.
- Identifying and presenting the position of the mobile devices at the site of the museum where there is a wireless network infrastructure on the basis of information from the subsystem NSS. This feature has three objectives.
  - Present the location of the device/visitor within the smartphone application museum map.
  - Updating the position of the device in NSS subsystem.

  - Show the position of the device/visitor within the smartphone application museum map of other devices/visitors usually of the same tourist group with the visitor (e.g. fellow student, family member etc.).

- Network management and instant messaging.

4.1.2 Underlying Infrastructure for the Smartphone App: Cell Application

Overview/Operations: The Cell Application implements communication among the Application of Presentation Multimedia Data, Instant Messaging Application and Positioning Application, as well as communicating with the NSS. It is somehow a cell, which consolidates these three applications. For example, when the Positioning Application detect the position of the visitor in the area of the museum notify the cell application and it undertakes to inform the NSS subsystem and the Application of Presentation Multimedia Data.

Briefly, the operations provided by the Cell application layer are as follows:

- It constitutes the administrator of communication between the remainder three applications.
- It allows the communication with the other subsystems.
- It manages the situations of errors.
- It manages the messages that are presented in the user.
- It manages the situations of network loss.

4.1.3 Presentation Multimedia Data

Overview/Operations: The main role of this application is the presentation of multimedia data in multiple languages. More specifically, the application has the following features:

- Provides a multimedia presentation of data in different languages and for the case study present there are four (4) languages available. It is possible to extend the localization and provide any number of different languages using the XML based on the dynamic configuration designed for the proposed personalized museum assistant.
- It provides two types of operation: Auto (changing the content presentation automatically depending on the position of the user in the museum) and Manual.
- It provides three types of presentations: Passive Acoustics (the visitor may listen to provided guided tours using the automatic recommendations based on his/her location in the museum—as a consequence the visitor just hangs the museum guide from his shoulder or neck and walks around the museum freely), Interactive Acoustics (the visitor may choose among the presentations available for

the exhibits) and Audio-Visual (the visitor may choose among the multimedia presentations available for the exhibits at his/her own pace).
- Interacts with the Core Application in order:
  - to receive data concerning the location/position of visitors in the museum (indoors and outdoors) and behaves accordingly
  - to receive the name of the visitor and display it in the welcome message
  - to deliver messages which should be displayed at the user
  - to manage the exception cases in lack of network or positioning into an exhibition hall
  - to set the language of the application upon registration.
- It manages with appropriate updates to the user situations where there is no network and cannot locate the exhibition hall in which the visitor is the given moment.
- It provides the possibility of depiction of place of user in the museum map. This map functions also as a means of navigation in the application.
- It dynamically presents application data using external image files (.jpg format), video (.swf Flash format) and audio (.mp3 format). Thus it is very easy to change the content of the application. The same is true with all the text that exists in implementation. The place of files is given dynamically from Core Application.
- It provides the possibility of on-line help in the user.

4.1.4 Instant Messaging Application

Overview/Operations: The Instant Messaging application gives the possibility in each visitor of directly communicating with text messages with the users that belong in the same team of users thus as they were declared at the process in the MDMDS. Also allow each user to receive alert messages from the system administrator through the Monitoring and Management Visitors Administration Console. Analytically, the operations that provide the particular application are following:

- Sending and receiving messages via direct keyboard users who have been declared in the same group of users.
- Display the state of Presence (Online/Offline) for specific users.
- Get information messages from the administrator of system.
- Display of position (at the hall) of users reported in the same group of users.
- Display of language of users that has been declared in the same team of users.

4.1.5 Positioning Application

Overview/Operations: Using the available Wi-Fi network, the topology of exhibition halls and the wireless network card that has a PDA, the Positioning Application undertaken to determine the position of each visitor to the site and then notify the Cell Application to manage this information.

4.2 Mobile Devices Management and Disposal Subsystem

This subsystem includes the management of the carousel, the management of incoming and outgoing visitors, the preparation of MDSC during the charging and the updating of data in MDSC, as these are taken from the DMS subsystem and the operation/subsystem issuing data for portable devices.

4.2.1 Operational Specifications of Mobile Devices Management and Disposal Subsystem

The basic functional specifications of the subsystem in relation to other subsystems operating PDA applications are as follows:

- Management and monitoring of visitors at dispense and return of equipment process and setting groups of visitors.
- Update subsystem MDSC and NSS (user and group information at the Communication server) for instant messaging (groups).
- Update of multimedia data with new versions in MDSC as taken by the NSS subsystem and other necessary files for the functioning of the MDSC per PDA (executables, file XML, etc.) are available in pre-spatial point. This procedure is performed when the PDAs is in the carousel.
- Turns in running the MDSC application (kiosk mode), shortly before the PDA charged to a user, with available network connection (it checks the availability from the MDSC), with turned on and regulated the backlight, turbo CPU mode, the sound as expense in headset exclusively, network regulations (IP, DNS) and with checked the state of battery.

4.2.2 Interaction with Other Subsystems

This subsystem communicates with the MDSC subsystem to carry out the functions 2, 4 as described above. If it does not make this process the PDAs cannot be used. The MDSC interact with NSS to be informed about any available new versions of multimedia data needed to be transferred in accordance with the operation 3.

4.2.3 Correct Operation Issues

In each appliance in MDSC subsystem exist various files of application in a specific point thus as they are created afterwards the process of installation. During the upgrade process may need some files to be replaced later with files from MDMDS. It is also worth noting that each device in MDSC subsystem linked to a user of the NSS and more specifically with a user of Communication Server. The MDMDS subsystem should write to each mobile device a file of user information.

4.3 Networking Services Subsystem

This subsystem includes services and management functions of the MDSC subsystem such as location positioning, monitoring the location of visitors inside the museum, where WNIS and Communication Server is available.

It consists of the following two applications:

- Communication Server
- Monitoring and Management Visitors Administration Console.

The following are the general operating requirements of the subsystem, the way interfaces with other subsystems and analyzed in greater depth the applications that compose the particular subsystem.

4.3.1 Operational Specifications of Networking Services Subsystem

The basic functional specifications are as follows:

- Monitoring the position of visitors inside the museum in real time according to information received from the MDSC subsystem where WNIS and Communication Server are available.
- Send information messages to visitors as a unit, group or exhibition hall.
- Communication Server.

4.3.2 Interaction with Other Subsystems

The NSS ties with MDSC for sending and receiving messages. This happens through the communication server, which will be analyzed afterwards. The NSS also informed by the MDMDS with incoming and outgoing groups of visitors. The NSS makes dependent the operation completely from his availability of access on the WNIS.

4.3.3 Communication Server

Overview/Operations: This server other than the operation in support of Instant Messaging operates as a Communication Server to link subsystems. More specifically throughout the following:

- Any device (PDA) that runs the MDSC subsystem sends information about its position and the language of choice of the visitor on the Communication Server so that it manage the information encouraging them to the Monitoring and Management Visitors Administration Console Application and other users in the same group of users.
- Creation of users and user groups. NSS subsystem manage so that users belonging to the same group to share their presence. The concept of presence is the meaning of the situation of each user. For example, if a family consisting of father, mother and child come to the museum will have during the check-into join the same group with the result that everyone in this group can see at any time if any of the members of the same group is connected, in which exhibition hall he/she is found the given moment and may send a text message.

4.3.4 Monitoring and Management Visitors Administration Console

Overview/Operations: The functionality of the application divided into the following two sections:

- The first part deals with the implementation of sending and receiving text messaging with all users of the system inside the museum.
- And the second section aims to give to the system administrator an overview of what happens inside the museum in real time.
- More specifically, through this application achieved the following:
- Monitoring the position of visitors in real time according to information received from the MDSC subsystem and operation of positioning where is available and properly configured the WNIS.
- Send information messages to visitors at:
  - single visitor,
  - specific language group,
  - specific exhibition hall group.
- Management of predefined messages.
- Group contact by language and location (exhibition hall).
- Presentation of number of visitors and language of these on a map.
- Management of presentation of visitors in the map (definition top-level visitors per room with a color code).
- Instant Messaging Logging (history).

- Logging the position of the visitors inside the museum in order to come out traffic statistics for each exhibition hall.
- Recording the presentation language of visitors in the MDSC in order to come out statistics.

4.4 Data Management System

The data management system (DMS) includes the operation of publication of multimedia data and additional files with settings (new versions). Once a new update data from the DMS, these data pass into MDMDS, to transfer data to devices. This subsystem is linked solely to MDMDS. Once a new updated data from the DMS, these data pass into MDMDS, to transfer data to devices. The particular sub system is interlinked exclusively with the MDMDS.

4.5 Wireless Network Infrastructure Subsystem

The wireless network infrastructure subsystem (WNIS) contains the necessary infrastructure for the availability of wireless interconnection of MDSC, and necessary facilities for the successful positioning operation of a device/visitor, wherever available. To achieve the positioning operation of a device/visitor ought to be regulated according WNIS and as this will be determined during the process of calibration of PDAs in the area of the museum.

5 Indoor Positioning and Technologies

This section describes the technologies involved in the development of the proposed applications and the development tools used to design and implement them.

5.1 Microsoft .NET Compact Framework

The Microsoft .NET Compact Framework (.NET CF) [12] is a version of the .NET Framework that is designed to run on Windows CE based mobile/embedded devices such as PDAs, mobile phones, factory controllers, set-top boxes, etc. The .NET Compact Framework uses some of the same class libraries as the full .NET Framework and also a few libraries designed specifically for mobile devices.

In addition, .NET Compact Framework makes possible to host ActiveX Controls (Flash Player controls in our case) in an application that uses the .NET Compact Framework.

5.2 XMPP Protocol

Extensible Messaging and Presence Protocol (XMPP) [13, 14] is an open, XML-inspired protocol for near-real-time, extensible instant messaging (IM) and presence information. The protocol is built to be extensible and other features such as file transfer and Voice over IP have been added.

5.3 Openfire

Openfire [15] (previously known as Wildfire Server) is a Jabber/XMPP server written in Java. It allows the implementation of XML based messaging services to inform and allow inter communication of the visitors chat clients.

5.4 Windows Media Player Mobile

Media Player Mobile [16] closely resembles the capabilities of the Windows version of WMP. Windows Media Player Mobile software includes a default skin which is a customized user interface to Windows Media Player that provides a unique appearance and functionality for Windows Media Player Mobile. You can create your own buttons in order to seamlessly integrate your customized skin with your application.

5.5 Macromedia Flash Player

The development platform used for the creation of this application is Macromedia Flash Professional [17]. The software used on customer to run the application is Macromedia Flash Player [18]. The Flash is a tool used by designers and developers responsible for creating presentations, applications and in general content that enables interaction with the user.

5.6 Microsoft Visual Studio

Microsoft Visual Studio [19] is the main Integrated Development Environment (IDE) from Microsoft. It can be used to develop console and graphical user interface applications along with Windows Forms applications and web applications in both native code and managed code for all platforms supported by Microsoft Windows, .NET Framework and .NET Compact Framework. Visual Studio Team System provides a set of software development, collaboration, metrics, and reporting tools in addition to the features provided by Visual Studio Professional.

6 Case Study: The Digital Exhibition of the History of Ancient Olympic Games and Application Visual Evaluation

This section presents the architectural design, implementation aspects and functional details that were taken into consideration in the implementation of a real-world, large-scale system for the Digital Exhibition of the History of Ancient Olympic Games.

Language Selection: Initially, the visitor has to choose the language of the presentation as shown in Fig. 2a. This screen serves as a boot option for the user, which means that unless the user chooses the language, the service will not proceed (whether or not moving in the museum). The design of the systems allows the integration of new languages with no restrictions.

Operation Type Selection: The visitor is possible to choose among the different operation types in the respective selection screen (Fig. 2b). The user is required to select the type of operation that is automatic operation (automatic positioning of the user current position inside the museum using the Wi-Fi network) or manual (the visitor choose manual the presentation of a thematic section which would like to attend).

Tour Type Selection: Then the user will see the tour type selection screen (Fig. 2c). Options include audio tour where the visitor listens for each thematic section a brief tour, detailed audio tour where outside short acoustic tour on the thematic sections, the visitor can hear also the keys tours and finally audio-visual tour where the visitor listens but also watches video and images.

Then, depending on the type of operation the user has chosen there are the following options:

1. In case of choosing an automatic type of operation, if it is detected within an exhibition hall: (a) If yes, the application loads the presentation for the corresponding thematic section. (b) If no (for example the visitor may be at the cafeteria), the system will inform the user that is standing outside of any exhibition hall and goes into standby mode until the user to enter an exhibition hall.

Fig. 2 Mobile application screenshots starting from *upper left corner*. **a** Language selection. **b** Operation type selection. **c** Tour type selection. **d** Exhibition halls—thematic sections selection screen

2. In case of choosing a manual type of operation the user will redirect to the Thematic Section Selection Screen (Fig. 2d) and the user will manually select the presentation of a thematic section which would like to attend.

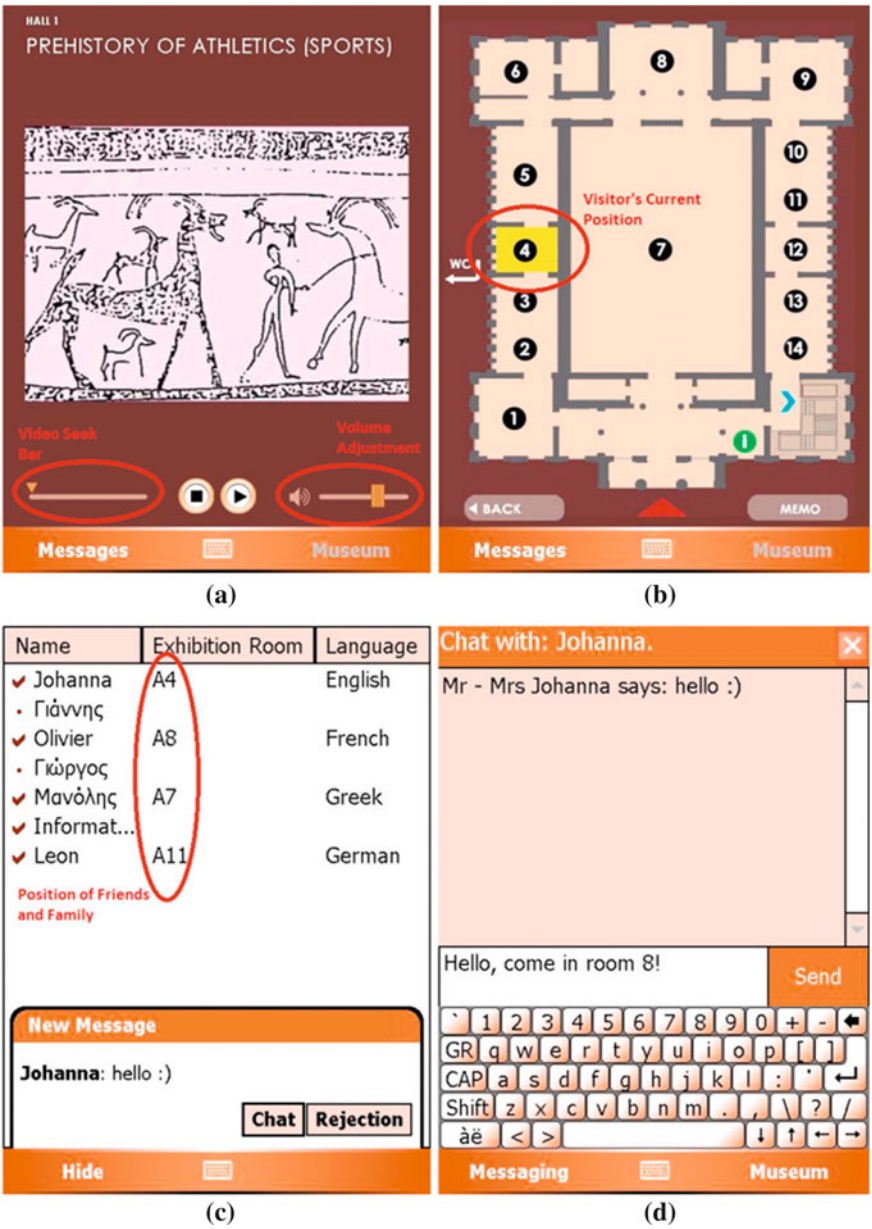

Fig. 3 **a** Audiovisual tour playback. **b** Museum map. **c** Contacts, positioning information and incoming notification bubble. **d** Mobile online chatting

Exhibition Halls—Thematic Sections Selection: After the user selects the manual type of operation will then receive a menu that contains all the exhibition halls—thematic sections (Fig. 2d).

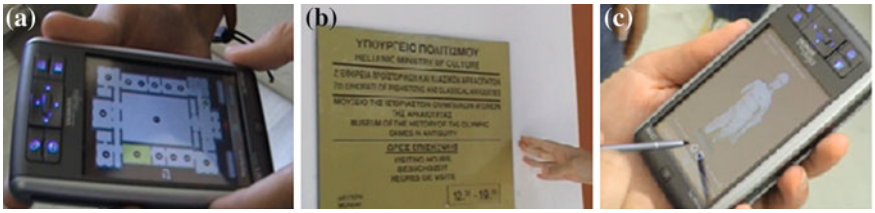

Fig. 4 Mobile application real life snapshots in the museum. **a** The visitor is automatically located automatically by the positioning system at the *yellow highlighted* exhibition room no. 5. **b** The entrance of the museum. **c** Watching and listening to a video

Instant Messaging Service: The Instant Messaging Service gives the possibility in each visitor of directly communicating with text messages (Fig. 3d) with the users that belong in the same team of users (Fig. 3c).

Positioning Service: The Positioning Service undertaken to determine the position of each visitor to the site (Figs. 3b, 4a).

Multimedia Data Provisioning: The main role of this service is the presentation of multimedia data in four languages (Figs. 3a, 4c).

7 Conclusions and Future Steps

In conclusion, the case study of the Digital Exhibition of History of Ancient Olympic Games in Ancient Olympia smartphone application for personalized recommendation museum guide has been presented. It allows the automatic indoor (and outdoor) location based recommendation for multimedia presentations about exhibits using Wi-Fi i.e. with no intervention in the museum. The proposed system is accompanied by all the supporting services and applications to provide excellent quality, innovative (state-of-the-art) technology results and efficient operational framework in real life museum. The key aim is to serve as a model for integrating ≪digital services≫ in museums and exhibitions in general with no limitations. The proposed recommendation museum guide solution is designed and provided as an integrated platform. As such it allows museum management and administration to extend or alter the exhibition adding or changing the exhibits in the future. Moreover, it is social web enabled as it allows to ≪link≫ with other museums around the world.

Future steps include the integration of image recognition features using the smartphone embedded camera. This will allow the user to watch or listen multimedia presentation in the paced—manual tour type after taking a photo of an exhibit. In this way the manual choices will turn to semi-automatic recommendations with user intervention. Furthermore, study towards the use of the mobile's camera in order to deliver augmented reality services upon exhibits indoors is also a possible direction. In fact, *indoor* augmented reality is currently implemented using either explicit user intervention or using standing (not mobile) cameras and completely differs from outdoor augmented reality approaches.

References

1. Chou, L.D., Lee, C.C., Lee, M.Y., Chang, C.Y.: A tour guide system for mobile learning in museums. In: Proceedings of the 2nd IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE'04), p. 195 (2004)
2. Fantoni, S.F.: Personalization through it in museums. Does it really work? The case of the marble museum website, Carrara Marble Museum, Cultural Institutions and digital technology, Ecole du Louvre, Paris, France (2003)
3. Allison, D., Gwaltney, T.: How people use electronic interactives: Information age—people, information and technology. In: Bearman, B. (ed.) Proceedings of the First International Conference on Hypermedia and Interactivity in Museums (ICHIM'91). Archives and Museum Informatics, PA, pp. 62–73. Pittsburgh, 14–16 Oct 1991
4. Chen, Y.C., Chiang, J.R., Chu, H., Huang, P., Tsui, A.W.: sensor-assisted Wi-Fi indoor location system for adapting to environmental dynamics. In: Proceedings of MSWiM '05. Montreal, Quebec, Canada, 10–13 Oct 2005
5. Farina, N.: Why indoor navigation is so hard—your phone can get you to the museum, but it can't guide you to the T-Rex. http://radar.oreilly.com/2011/10/indoor-navigation.html (Cited 15 June 2012)
6. Garofalakis, J., Sakkopoulos, E., Sirmakessis, S., Tsakalidis, A.: Integrating adaptive techniques into virtual university learning environment. In: Proceedings of the IEEE International Conference on Advanced Learning Technologies, pp. 28–33 (2002)
7. Koshizuka, N., Sakamura, K.: Tokyo university digital museum. In: Proceedings of the Kyoto International Conference on Digital Libraries (2000)
8. Lonsdale, P., Baber, H., Sharples, M., Byrne, W., Arvanitis, T. N., Brundell P., Beale, R.: Context awareness for MOBIlearn: Creating an engaging learning experience in an art museum. In: Proceedings of the 3rd MLEARN Conference, Rome, Italy, pp. 115–118 (2004)
9. Gemmell, J., Bell, G., Lueder, R., Drucker, S., Wong, C.: My—LifeBits: ful_lling the memex vision. In: Proceedings of the ACM Multimedia, pp. 235–238 (2002)
10. Healey, J., Picard, R.W.: StartleCam: A cybernetic wearable camera. In: Proceedings of the 2nd IEEE International Symposium on Wearable Computers, p. 42, 19–20 Oct 1998
11. Kawaji, H., Hatada, K., Yamasaki, T., Aizawa, K.: An image-based indoor positioning for digital museum applications. In: Proceedings of the 16th International Conference on Virtual Systems and Multimedia (VSMM), pp. 105–11 (2010)
12. Microsoft .NET Compact Framework 3.5—http://msdn.microsoft.com/en-us/netframework/aa497273.aspx (Cited 15 June 2012)
13. agsXMPP SDK—http://www.ag-software.de/index.php?page=agsxmpp-sdk (Cited 15 June 2012)
14. XMPP Protocol—http://www.xmpp.org/ (Cited 15 June 2012)
15. Openfire—http://www.igniterealtime.org/projects/openfire/index.jsp (Cited 15 June 2012)
16. Windows Media Player Mobile—http://www.microsoft.com/windows/windowsmedia/default.mspx (Cited 15 June 2012)
17. Macromedia Flash Professional 8—http://www.adobe.com/products/flash/ (Cited 15 June 2012)
18. Macromedia Flash Player 7 for Pocket PC—http://www.adobe.com/products/flashplayer_pocketpc/ (Cited 15 June 2012)
19. Visual Studio 2008—http://msdn.microsoft.com/en-us/vstudio/products/default.aspx (Cited 15 June 2012)

Author Biographies

Mersini Paschou has graduated from the Department of Computer Engineering and Informatics of the University of Patras in 2007 and obtained M.Sc. degree in "Computer Science and Engineering" in 2009. Currently, she is a PhD candidate of the same department. She has been a member of Graphics, Multimedia and GIS Laboratory since 2006 and has participated in numerous National and European projects as a software engineer. Her research interests focus on the areas of Web Services, Information Systems, Web Technologies and Mobile Web Applications.

Evangelos Sakkopoulos was born in Greece, in 1977. He holds a PhD from the Computer Engineering and Informatics Department, University of Patras, Greece since 2005. He has received the M.Sc. degree with honors and the diploma of Computer Engineering and Informatics at the same institution. His research interests include Software Engineering, Mobile Apps, Web Services, Web Engineering, Web based Education and Intranets. He has more than 40 publications in international journals and conferences at these areas.

Athanasios K. Tsakalidis was born in Katerini (Greece) in 1950. In 1973, he obtained his Diploma of Mathematics from the Mathematics Department of Aristotle University of Thessaloniki (Greece). In 1981 he obtained his Diploma of Informatics from the University of Saarland, Saarbuecken (Germany) and in 1983 he obtained his PhD in Computer Science from the same University. For 12 years, he was the student and colleague of Professor Kurt Mehlhorn (Director of Max-Planck Institute of Informatics in Germany). Today, he is a Professor in Computer Engineering and Informatics Department of University of Patras, in which he was chairman for 8 years. He was member of the Board of Directors of R.A. Computer Technology Institute (R.A.CTI), Research and Development Coordinator of the same Institute, for 10 years. His research interests include: Data Structures, Graph Algorithms, Computational Geometry, Expert Systems, GIS, Medicine Informatics, Database Systems, Multimedia, Information Retrieval, and Bioinformatics. He co-authored chapter "Data Structures" of "Handbook of Theoretical Computer Science" (Elsevier Publications and MIT-Press 1990, work of 48 authors from 12 states). He has also authored more than 200 papers in international journals and international conferences proceedings with special contribution in resolution of basic problems in the area of data structures.

Giannis Tzimas is currently an Assistant Professor in the Department of Applied Informatics in Management and Finance of the Technological Educational Institute of Mesolonghi. Since 1995, he is also an adjoint researcher in the Graphics, Multimedia and GIS Lab, Department of Computer Engineering and Informatics of the University of Patras. He graduated from the Computer Engineering and Informatics Department in 1995 and has participated in the management and development of many Research and Development projects funded by national and EU resources, as well as the private sector. He also works in the Internet Technologies and Multimedia Research Unit of the Research Academic Computer Technology Institute (RACTI), as a technical co-ordinator, from 1997 till now. His research activity lies in the areas of Web Engineering, Web Modelling, Bioinformatics, Web Based Education and Intranets/Extranets. He has published a considerable number of articles in prestigious national and international conferences and journals.

Emmanouil Viennas was born in Athens, Greece in 1985. He received the Diploma of Computer Engineering and Informatics in 2008 and the master degree in Computer Science and Engineering in 2010, both from University of Patras, Greece. His research interests lie in the areas of Web Engineering, Software Engineering, Mobile Applications and Information Systems. He is the author of more than 10 technical papers published in international journals and conferences. He is a member of the Institute of Electrical and Electronics Engineers (IEEE), the Association for Computing Machinery (ACM), the Technical Chamber of Greece and the Hellenic Association of Computer Engineers and Communications.