Fusion of multimedia and mobile technology in audioguides for Museums and Exhibitions: from Bluetooth Push to Web Pull

Jean-Pierre Gerval¹, Yann Le Ru¹

¹ Institut Supérieur de l'Electronique et du Numérique - Brest
20 rue Cuirassé Bretagne, CS 42807
29228 Brest cedex 2, France
{jean-pierre.gerval, yann.le-ru}@isen.fr

ABSTRACT. This paper introduces software developments targeting visitors in museums. The main idea leading to these projects is to implement low cost systems that would provide visitors with informational contents about paintings, artworks, etc. The first application was achieved by means of a system that sends a multimedia content (images, audio and texts) to a visitor's mobile phone when the mobile phone is in communication range of a Bluetooth transmitter. The second application is an authoring tool that does not require any software development skill. Curators can set up easily and quickly contents for the visitors. Experiments took place in a Marine Park where more than 200 contents had been developed. It is a web-based system. On smartphone side, HTML5, JavaScript and Ajax technologies enable us to target a wide range of devices. In the last part of the paper we compare these two approaches and we also open some new opportunities of developments taking into account our experiences.

Keywords: Audioguides, Authoring tool, Bluetooth, Exhibitions, Multimedia, Museum, Smartphone, Web

1 Introduction

This paper sets out software developments and experiments targeting visitors in museums. Nowadays most people own a smartphone. Most of them use their smartphone to listen to music, to watch videos, to keep in touch with their social networks... This paper aims to describe new approaches in the field of audioguides development that fit with these new technologies. Our motivation for the development of such tools is twofold.

On the one hand, a goal is to replace existing audioguides systems in order to reduce exploitation costs. Existing systems require specific equipment. They are expensive to buy and to maintain. In some museums the technologies used are out of date and budgets for culture granted by the public authorities are rarely rising. Using visitors' smartphone is a good way to reduce investments and maintenance costs. However, some world-renowned museums have larger budgets, for example the Louvre

museum. The Louvre Audio Guide [1] is available on App Store or Google play for iPhone or for Android. The Louvre museum also rents Audio Guide on Nintendo 3DS. There are 3D photos of the galleries, high-definition images, and 3D reconstructions.

On the other hand, the aim is to increase the interest of young people by means of new tools that implement new technologies. Museums do not always have the reputation of being attractive to young people.

In the first part of this paper we describe an application that was developed for a small painting exhibition. This development had been achieved with the municipal Museum of Pont-Aven [2]. This museum was created in 1985 in order to promote the artists who drew their inspiration from Pont-Aven. The well-known Pont-Aven School emerged around Paul Gauguin in Brittany between 1886 and 1896.

The main idea, which leads to this work, is to implement a low cost system that will provide visitors with informational content about paintings. Such a system can replace traditional audioguides that are rented to visitors.

Multimedia contents are pushed on the smartphones (either mobile phone) of the visitors by means of a Bluetooth connection to a server. In [3] authors discuss about *"how to transmit and install software for audioguides and to evaluate the interoperability of different devices regarding to the technology"*. They conclude that *"Bluetooth is the most attractive way to provide software for audioguides in a museum or exhibition, because it is a cost effective way to transmit data"*. One disadvantage of this solution is the complexity of the installation process. In our application we pay special attention to the usability of the installation process: the user just has to activate Bluetooth on his smartphone and to wait for the content to be downloaded.

A quick overview of developments in this field points out at first the use of Personal Digital Assistant (PDA) that supports interactive applications to deliver rich media, such as audio and video, to visitors. An interactive handheld museum guide on Pocket PC [4] was developed, implemented, and evaluated by the Blanton Museum of Art at the University of Texas at Austin in collaboration with UT's Information Technology Department. The evaluation pointed out that a majority of visitors were satisfied. In addition technical lessons were learned, for example: battery life was too short; Pocket PC was fragile; Pocket PC was easy to use, *"even by people with no prior computer or handheld experience..."* Nowadays, battery life is getting longer but attention should be paid to offer visitors solutions to recharge their devices when necessary. In our experiments we are targeting visitors' smartphones. It can be expected that the visitors take care of their smartphones.

It is confirmed by [5] that one of the best improvements for their system was making the PDA more reliable. They also point out that: *"The best way to distribute the PDAs and teach visitors how to use them was a constant work in process"*. We wish to avoid such a situation that appears when PDAs are rented or lent to visitors.

The same finding stands in [6] where authors had experimented an audioguide based on the Apple iPod touch: *"The operations of an audioguide are explained and learned in seconds, while any PDA class device requires minutes, a time span unbearable in large museums"*. We can expect that using visitors' smartphones is a good way to reduce the time that the visitors need to understand operations.

In their work concerning a location sensitive multimedia museum guide [7] authors point out that *"users tend to stop playing audio media after a specific time"* and that *"users want more audio instead of text content"*. This is an interesting fact that we have to take into account: audio or video files that are too long can distract visitors from the goals of the exhibition. We also have to be aware that *"the richness of the personal interactive multimedia technology risks to divert the user's attention from content to presentation"* [6].

Other examples of developments [8] [9] [10] provide more added value to visitors by means of objects recognition in museums based on images which are taken directly by the visitor. The image is sent to a server; objects are recognized and then the requested information is sent to the visitor. These applications are exciting but they require many types of equipment such as PDA or tablet PC, network infrastructure and servers with database. Such applications are well suitable for large museums. It *"saves museum curators from distributing and maintaining a large number of physical (visible or invisible) tags"* [10].

Radio-frequency identification (RFID) may also be associated to PDA [11]. The PDA RFID readers identify the related objects. Detailed content is then downloaded via the wireless network and presented on the PDA. Such a technology sounds appropriate for large rooms where artworks are not too close to each other. The authors found that: *"an interaction distance of approximately 15 centimetres between the HF RFID tag and the reader was reasonable. If the distance was too large, the reader sometimes simultaneously detected multiple tags"*.

In our case we were requested to provide a low cost system. For that reason we pay attention to mobile phones and smartphones. No need to provide any equipment to visitors because most of them own a mobile phone.

A lot of museums use mobile phones for tours, especially in the US. But it is not *"the great democratic tool for reaching new audiences in Europe"* [12]. On the one hand, many museums in Europe are located in historic buildings where mobile phone reception is poor. On the other hand, a lot of Europeans have 'pay-as-you-go' plans and so, higher per-minute call costs [12].

In order to avoid any additional cost for visitors, the idea is to push content (a multimedia application: images, audio, texts) to clients (mobile phone or smartphone) when they are in communication range of a Bluetooth transmitter.

There are many advantages for that solution:

- There is no cost for data transfer.
- The content is stored on the visitor's side and can be read at any time anywhere.
- The content can be easily transferred from one mobile phone to another.
- The visitor is requested to accept or refuse to download the content.
- It is easy to use and does not require any specific knowledge from the visitor.

The second part of the paper is dedicated to a large exhibition. The aim is to provide 'on-demand' multimedia contents to visitors and there are several hundreds of contents to design. This development had been achieved in cooperation with Océanopolis [13], a scientific marine park:

- 9,000 m2 of exhibition space
- 3 pavilions: tropical, polar, temperate
- 68 aquariums
- 4 million litres of seawater
- 1,000 species
- 10,000 marine animals
- close to 400,000 visitors per year

The challenge was twofold. On the one hand, it was to provide audioguides on visitors' smartphones at a large scale. On the other hand, it was to ensure that content development was as simple as possible.

There are many contents and there are many visitors using smartphones. This leads us to think about implementing a web solution to pull contents from the smartphones of the visitors. Most of the previous references deal with mobile applications that are targeting visitors. They rarely give details about the design of contents for museum.

In 1998, M. Hertzum [14] identified three typical problems faced by museum web sites:

- (1) *"The majority of the museum sites have been developed without a clear notion of what the site should achieve."*
- (2) *"The sites have not been evaluated to find out whether they match the users' needs and wishes."*
- (3) *"The material on the sites tends to duplicate material in the physical museums rather than to rethink it given the possibilities provided by the new medium."*

We believe that these three typical problems must be taken into account even if our target is to develop an audioguide system. With the advent of mobile media in museums, what is crucial from a design point of view is to define precisely what we offer as contents to the visitor and what we consider as necessary in the "Here and the Now of the practice" [15]. A study on mobile phone tours and audioguides at the Centre Pompidou in Paris [16] suggested the need for "*innovative multimedia search and navigation tools*" to cross-reference objects, information, and keywords.

In [17] there are also recommendations for a user-centred development of museum web sites. In our case we will focus on two kinds of users: curators and visitors.

When developing contents, special attention must be paid to design, information retrieval and reusability of contents. As it is suggested by [18] a model based on domain ontologies can enhance the informational potential of objects in a museum catalogue. It can ensure reusability of information. It may allow curators to work more efficiently, for example in identifying the relationship between a particular object and contexts of knowledge.

Different types of ontologies can be distinguished according to [19]:

- "*Domain ontologies*" representing knowledge for a particular domain (e.g. mechanic, electronic, medicine).
- "*Metadata ontologies*" describing the content of on-line information sources.

- "*Generic or common sense ontologies*" that aim at providing general knowledge about the world (e.g. time, space, state, event).
- "*Representational ontologies*" providing representational entities without stating what should be represented.
- "*Method and task ontologies*" providing a reasoning point of view on domain knowledge.

According to the context of our developments we have established three ontologies:

- A domain-specific ontology
- A metadata ontology
- A common sense ontology

The domain-specific ontology (Fig. 1) as mentioned above provides knowledge on a particular domain. Such ontology should be established by curators.

Fig. 1. Example of domain-specific ontology

The metadata ontology (Fig. 2) is linked to the domain-specific ontology by means of topics of interest that are chosen from the curator's point of view. This ontology is particularly interesting for the design of the Conceptual Data Model of the database. According to [20] concepts are organized via semantic relationships:

- Hypernymy: the taxonomic relationship ensures the inheritance of properties between concepts.
- Meronymy: the component relationship between concepts.
- Synonymy: the identity relationship that describes the similarity in meaning.

Fig. 2. Example of metadata ontology

The common sense ontology (Fig. 3) acts as a Use Case Diagram showing the usage requirements for the system: events and/or actions between users and the system.

Given the large number of contents to be designed an authoring tool (back office) was developed. This tool enables the curators and the museum staff to design their own contents by themselves. New contents will not require any new deployments. It is not necessary to modify and to compile any source code. This means that museum staff do not have to use any software development tools. Our motivation for the development of such an authoring tool lies in the fact that most curators have poor knowledge of web development and *"the staff's skill is critical in facilitating the didactical focus of such a roll-out"* [21]. We also provide curators with a data loader that retrieves elements from an Impress OpenOffice document and imports data into the database.

A quick market survey points out some existing tools [22] [23] that offer content generation by means of friendly interfaces targeting the web, IOS or Android... But they require knowledge in the handling of tools or they require some knowledge in

web design such as HTML or CSS. Our goal is to provide tools that do not need any computer skills from Museum staff. That is to say, a tool that is easy to use and simple to understand. Another problem lies in the fact that contents could be stored in the "Cloud". Due to intellectual property or plagiarism, most curators prefer to store their contents either on their own computers or on their local network.

Fig. 3. Example of common sense ontology

In the last part of the paper we compare these two approaches and we discuss about advantages, disadvantages and complementarities of such applications. We also open some new opportunities of developments taking into account our experiences.

2 Bluetooth push

2.1 Hardware requirements

Visitors need to use mobile phones or smartphones that support Bluetooth wireless technology.

The Bluetooth transmitter (Fig. 4) has been implemented on a personal computer. This was a request from the museum but Bluetooth Access Points that achieve the same job can be found on the market for a cost that does not exceed 400€. An example can be viewed in [24].

2.2 On server side

On the server side, the software is in charge of transferring the content to mobile phone or smartphones clients. This application has been developed using the BlueCove library [25] which is a Java library for Bluetooth. The OBEX (Object EXchange) protocol was chosen for data transfer because it is commonly available on mobile phones or smartphones that support Bluetooth wireless technology.

The software architecture (Fig. 5) is multithreaded. The main thread is in charge of discovering clients. The other threads are dedicated to data transfer to clients.

Fig. 4. Bluetooth transmitter

The basic behaviour of the server is shown Figure 6. After initializing the Bluetooth device we load configuration data: file name to transfer to clients, timeout for discovering clients, maximum number of clients to be served during one loop, duration to keep clients that were served into clients list (in order to avoid sending file to clients that were already served).

After loading configuration data, a three-step infinite loop starts:

- (1) Discovering new mobile phone clients.
- (2) Sending data to new clients that were discovered.
- (3) And finally, updating the list of clients that were served.

Fig. 5. Server UML diagram

Fig. 6. Server side: data processing

2.3 On client side

The client software has been implemented using J2ME (Java 2 Micro Edition) [26] and J2ME Polish [27].

These clients are especially dedicated to mobile phone, personal assistant and smartphone. J2ME Polish provides tools for mobile Java and cross-platform development

The main features of J2ME Polish include:

- A flexible User Interface toolkit; for example standard J2ME applications can be designed using CSS (Cascading Style Sheets) text files;
- Tools that enable the porting of an application to different equipment and also different operating system; for example it is possible to compile the same application for an Android or a BlackBerry device;
- Software components that enable the implementation of RMI (Remote Method Invocation) for accessing server side content and communicating with remote parties;
- Software components that make complex data persistence on devices easier;
- A large database of devices.

The content was designed so that changing data does not require changing any source code. Data are stored in folders (Fig. 7).

Fig. 7. Data: images, audio files and text files

It is easy to set up a new client application:

- The first step is to copy the right files in the right directories.
- The second step is to re-compile the client software.
- This way this application can easily be reused for new upcoming exhibition.

The visitor must choose a language (French or English) before getting access to the main menu. This menu shows the name of the paintings for which contents are available. When a painting has been selected the visitor can decide either to read the text or to listen to audio comments (Fig. 8). A paradox of the project was the fact that using mobile phone was not allowed in the museum. As a constraint, we had to set the volume of audio files as low as possible.

Fig. 8. Choosing a language, a painting and viewing data

2.4 Experimentation

The experimentation (Fig. 9) was carried out for six months. The exhibition received more than 30,000 visitors.

The main feedbacks were as follows:

- A lot of visitors were interested in this innovative proposal.
- The most receptive public with this application was the young public.
- Some visitors had difficulty in downloading contents and thus to use these comments while visiting.
- Those who were not able to download the application gave up.
- Downloading the application to mobile phone or smartphone was too long while there were only fifteen paintings that were described in this application.

- It would have been more efficient to provide one application per language. Thus the size of the application would have been smaller.

Fig. 9. Inside the museum

3 Authoring tool and Web pull

3.1 On server side

The system is built around a database (Fig. 10) where contents are stored. Content designers will feed the database using the Authoring tool. Visitors will get access to informational contents through a content generator (Fig. 11).

The database contains all the information required by the system:

- the contents of audioguides,
- the default configuration values of the system,
- the access codes and templates for the printing of tickets.

The contents of the audioguides are structured hierarchically (Fig. 12):

- A group is a set of applications that deal with the same topic. For example, it could be the same content provided in different languages. The visitor will get content according to the language they have chosen or according to their smartphone configuration. Generally a listening point number is associated to a group inside the museum or the exhibition.

Fig. 10. Database: conceptual data model

Fig. 11. System overview

- An application is a set of pages that describes a given topic. An index is generated that gives access to each of them.
- A page is a basic element of content. Each page may contain a title, an image, a textual description and an audio description.

Fig. 12. Content organization

The content generator extracts data from the database and provides HTML 5 pages through a template according to a theme and a type of transition between pages that have been defined by the content designer. The template is as simple as possible. It defines the look and feel of the content that will be viewed by the visitor.

This template has been implemented using jQuery Mobile [28]. jQuery Mobile is a framework that enables the design of responsive web site and applications. This way web sites and applications are accessible on various devices: smartphones, tablets, desktops. Using HTML 5 [29] allows us to provide content for various types of smartphone. HTML 5 is the 5th major revision of the core language of the World Wide Web: the Hypertext Markup Language (HTML). This way contents are viewable on visitors' own mobile devices. Contents are portable whatever the operating system. There is only one restriction at the web browser level: to be fully HTML 5 compliant.

In order to avoid lost or weak network connections and to improve the reliability of our system we use the cache-manifest functionality of HTML 5 that enables web contents to be viewed offline. The addresses of any resource that is required by the application to be rendered are copied into a manifest file. These resources are stored in the local cache of the web browser. In case of failure of the network connection, the web browser will use the local copies instead and will render the web application offline.

The Server and database implement Linux, Apache, MySQL and PHP. This architecture has come to be known simply as LAMP.

3.2 Authoring tool functionalities

The Home tab.

The active application is shown on the Home tab (Fig. 13). This is the application which is currently under editing. By default, we provide the content designer (i.e. a curator) with its first application retrieved from the database.

The Applications tab.

This tab (Fig. 14) enables the content designer to add a new application or to modify an existing application. An application is defined with the following arguments:

- a group name (i.e. a listening point number),
- a title,
- a colour theme,
- a type of transition between pages: slide up, slide down...
- an attribute that defines the language of the application,
- an attribute that defines the free availability or not of the application; in that case an access code will be required in order to access the content.

Fig. 13. Home tab

Fig. 14. Applications tab: generating a QR (Quick Response) code

The functionalities that enable applications management are the following:

- Deleting the application. All the pages of the application will also be deleted.
- Generating a QR code (Fig. 14) that will contain the URL of the application. QR codes are generated using an open source library: PHP QR Code [30].
- Copying the application in another group (or in the same group with another name). This could be useful for example to create a template for a new application in another language.
- Previewing the application (Fig. 15). A new window is opened and it emulates the application as if it was running on a smartphone.
- Editing the application. In that case the application runs into the active state and its pages can be edited. The active application is showed in red in the interface.

Fig. 15. Applications tab: previewing the application

The Pages tab.

The Pages tab is dedicated to the management of pages. A page is defined with the following elements (Fig. 16):

- a title,
- an image: we suggest that users provide a 200x200 pixels image as the screen of a smartphone is generally small,
- a textual description,
- an audio description: mp3 and/or ogg file. If there are two files the browser will choose automatically the one it can play.

Functionalities that enable pages management are the following:

- Deleting a page.

- Pushing up a page in the page list.
- Pushing down a page in the page list.
- Moving a page into another application.
- Copying a page into the same application or another one.
- Previewing the page. A new window is opened and it emulates the page as if it were running on a smartphone.
- Editing the page. In that case the page runs into the active state and it can be edited.

Fig. 16. Pages tab: editing a page

The Configuration tab.

The configuration tab (Fig. 17) is only available to administrators. They can define the default values of some attributes or parameters about applications and pages. The configuration tab also offers functionalities that enable the management of tickets and

access codes: generating new access codes, printing tickets, deleting obsolete codes from the database...

Some applications can be protected with an access code. In order to view protected contents, the visitor must buy a ticket (Fig. 18) and scan a QR code that contains the access code before having access to contents that are not freely available.

Audio Guide

audioguides.oceanopolis.com/adminConfig.php

Générateur d'Audio Guides

Home Applications Pages Configuration Help

Hi, do not forget to [logout](#) after your work!

Configuration

Applications

Default Theme: Blue/Grey

Default transition: flip

Default Language: Français (FR)

Default payment: ☒ Yes ☐ No

Pages

Menu to delete links: ☒ Yes ☐ No

Max file size: 2097152 bytes (image and audio files uploaded on the server)

Font size: 100 for the content area (% of the default value)

Other parameters

Title of this site: Audio Guide

Title of the Back Office: GGénérateur d'A

Scrolling marquee: © ISEN-Brest - Océanopolis - Audioguide (2012)

Back Office language: English (GB)

Back Office access code: bo

QR Code, error correction: L (7%) minimum (Redundancy %)

QR Code, size: 5 (each code square will be 5*5 pixels)

QR Code, margin: 2 (code will have 2 code square(s) white boundary around)

Theme of service pages: Green/Yellow

Access codes Create codes Print magic code Print codes

Paper size: ☒ A4 ☐ A3

Paper orientation: ☒ Portrait ☐ Landscape

Ticket mask: Format 1 (/var/www/hosts/audioguides.oceanopolis.com/httpdocs/ressources/ticketHorizontal.png)

Ticket title: audioguides.oceanopolis.com

Edit current printing configuration

Available Code(s): 2293

Fig. 17. Configuration tab

Fig. 18. Sample ticket

Fig. 19. Activity diagram: visitor scans ticket QR code

Fig. 20. Activity diagram: visitor scans content QR code

A server key which is stored in the database is used to generate the QR code of the ticket. A client key is generated when the visitor scans this QR code. This client key is stored in the database and also in the memory of the browser using HTML 5 local storage Object (Fig. 19). This way it is not possible to use the same ticket on different smartphones and the client key will not be deleted when the browser is closed.

Then the client gets access to all protected contents during their visit in the museum or the exhibition (Fig. 20). A time stamp is also recorded in the database. This way the lifetime of a protected content can be limited in time.

3.3 Data loader: from OpenOffice to the database

OpenOffice Impress is a multimedia presentation tool equivalent to MS-PowerPoint. Most people know how to handle these tools. Instead of using the authoring tool, the content designer can import an OpenOffice presentation to create a new application including group number, language and pages content. The tool must create the group if it does not exist.

Open document format.

The “open document format” is an open XML-based document file format used in several presentation documents such as OpenOffice [31]. An odp file is a java archive (Fig. 21) containing xml files.

Name	Size
Configurations2	0
META-INF	1 366
Pictures	162 105
Thumbnails	17 979
mimetype	47
content.xml	18 075
settings.xml	9 470
styles.xml	44 047
meta.xml	1 189

Fig. 21. Open document format archive

The interesting parts of this archive, for a data loader to retrieve information are:

- "content.xml": content of the document including pages and frames
- Pictures: directory containing pictures

The structure of the "content.xml" file depends on the document type. For presentations, the main XML elements are listed hereafter.

Table 1. Main XML elements of context.xml

Element	Parent element	Description
office:document-content		root element
office:body	office:document-content	content of the document
office:presentation	office:body	kind of document
draw:page	office:presentation	element containing all the graphic objects of the page
draw:frame	drawn:page	frame on the slide
draw:text-box	drawn:page	text-box
draw:image	drawn:frame	image
draw:plugin	draw:frame	plugin such as video or sound
text:p	elements containing text	paragraph

An image is represented by a <draw:image> element and a media file by a <draw:plugin> element. Both own a “xlink:ref” attribute which is a reference to the image or media file.

For images, it begins with “Pictures”, directory included in the archive, and is followed by the internal file name.

Media files are located outside the archive, and therefore begin with “..” to get out of the archive and is followed by the path to the file.

All texts, such as titles or paragraphs, are inside a <text:p> element.

OpenOffice Impress file structure.

In order to retrieve information automatically from the OpenOffice Impress file, this one must respect a few constraints:

- First the document’s name is composed of the number of the group and the locale used, such as “360.en_GB.UTF-8.odp”.
- Second, the structure of each page follows the template described hereafter (Fig. 22).

Each page contains four frames which are identified by the name attribute to facilitate the data processing:

- title: named “title_i”
- textual description: named “description_i”
- image: named “image_i”
- audio description: named “audio_i”

where “i” is the number of the slide.

Fig. 22. OpenOffice Impress template

Fig. 23. OpenOffice Impress file example named "360.en_GB.UTF-8.odp"

For example, text and image from the page shown in Figure 23 are represented as follows in the "content.xml" file.

```

<draw:page draw:name="page1" .../>
...
<draw:frame draw:name="description_1" ...>
  <draw:text-box>
    <text:p>
      Welcome to the third part of our trip
      ...
      a defence against predators
    </text:p>
  </draw:text-box>
</draw:frame>
...
<draw:frame draw:name="image_1" ...>
  <draw:image xlink:href="Pictures/DF4365.jpg" ...>
    <text:p/>
  </draw:image>
</draw:frame>
...
</draw:page>

```

Data Loader.

The data loader is composed of three modules in order to simplify software prospective evolutions.

The first one is the Man-Machine Interface (MMI) module. This module is available from the “Help” tab of the back office. The page includes an example and a template to help content designer in the presentation creation process; a form to upload the archive file composed of the odp file and an “audio” directory containing the audio files; and text-box to give a feedback to the user on the generation process.

The second one is a parser module. Its purpose is to check the documents included in the archive and to retrieve the information. After decompressing the archive, the software proceeds in verifications on the filename’s constraint. It then checks each slide and retrieves information by parsing the “content.xml” file. If everything looks good, all the information is kept in variables which are sent to the integration module, otherwise a feedback message identifying the problem is raised and sent as feedback to the MMI module.

The last one is the integration module. Its aim is to populate the database with the information by creating a new group and/or by adding a new application to a group. A feedback is also sent to the MMI module.

3.4 On client side

When the visitor buys a ticket and scans the QR code a test screen (Fig.24) is rendered on their smartphone. This screen has been implemented in order to make sure that:

- The smartphone can read QR codes.
- The web browser can play audio files.
- The web browser is HTML 5 compliant, especially for manifest and local storage.

On this screen the visitor can also choose a favourite language.

Fig. 24. Test screen

In order to get access to audioguides during a tour in the exhibition the visitor must scan QR codes. These QR codes are deployed within the exhibition next to displays that shows the number of the listening point (Fig. 25).

Once the client (i.e. the visitor) is connected to the server, an index page is presented (Fig. 26). By clicking on an image they can choose the page they wish to consult. The page is loaded in the browser and the audio file start to play.

Fig. 25. Scanning QR codes

Fig. 26. On the visitor's side

A Navigation tab (Fig. 27) enables the visitor to change group and then to get access to any content they are allowed to view. They only have to enter the name of the group or the listening number.

Through the option tab, they can choose another language both for contents and user interface. A survey screen is also available (Fig. 27). The target is to get feedbacks and comments from visitors about the features of the audioguides.

For the application to work properly, there are only four constraints to be respected:

- Using an HTML 5 compliant browser (Google Chrome for example).
- Enabling JavaScript.
- Accepting cookies.
- Not clearing the browser cache.

Fig. 27. Navigation tab and survey screen

3.5 Experimentation

A first prototype with only five groups had been deployed for two weeks for testing purpose. The survey module was activated and we got interesting feedbacks from visitors:

- QR codes next to displays are insufficiently illuminated for smartphone reader.

- In the darkness the flash lamp shines the QR code.
- There is no option for manually entering the number of the listening point.
- Tickets already used or expired are distributed at the entrance.
- WiFi coverage is poor.

According to these feedbacks:

- Special attention was paid to the location of QR codes inside the different pavilions.
- The navigation tab was added to the client software.
- We discovered that some QR code readers were sending a HTTP HEAD Request while we were expecting to receive a HTTP GET Request.
- The WiFi network was fully deployed before going into production.

Some results from the survey are presented hereafter (Fig. 28) (Fig. 29) (Fig. 30).

Most users were satisfied with functionalities that the software offers and its ergonomics. 55% of the users were unsatisfied with the application response time. This was due to a lack of bandwidth of the WiFi network.

As a result when the application went into production, 60 groups were created and 222 applications were developed for a total amount of 343 pages. Four languages were available. All the contents were developed by people without any experience in Computer Science.

We got 1,992 connections from visitors. Most users were satisfied and especially foreigners who got contents automatically in their native languages. Today this authoring tool has been tailored for a multi-user context in order to allow each content designer to manage their own material.

Fig. 28. Are you satisfied with the functionalities of this guide?

Fig. 29. Are you satisfied with the ergonomics of this guide?

Fig. 30. Are you satisfied with the response time of this guide?

To complete the Authoring tool we provide a statistical module that gathers information about visitors on a chosen time period:

- The number of connections we got for each application.
- The language in which the content was downloaded by a visitor (Table 1).
- The operating system which was used by a visitor (Table 2).

Table 1. Statistical results for languages

Languages	
French	67.2 %
German	22.0 %
English	6.5 %
Italian	4.3 %
TOTAL	100 %

Table 2. Statistical results for operating systems

Operating Systems	
iOS	51.5 %
Android	45.3 %
Windows Phone	2.2 %
Blackberry OS	0.8 %
Others	0.2 %
TOTAL	100 %

4 Discussion and prospects

Using a Bluetooth device in order to push a large amount of data on smartphone does not sound appropriate. This is less flexible to manage when contents are subject to evolve. If we want to implement large applications then we have to multiply access points. Therefore using such a system can quickly become complicated for the visitor.

Nevertheless we believe in that solution; especially for short contents. Another interest lies in the fact that it does not require any network infrastructure such as a WiFi network for example. Also it does not require any skill from any staff except to be able to start and to stop the device.

The web based approach is suitable for huge exhibitions where there are a lot of topics to be explained to visitors. It requires a network infrastructure such as WiFi. But as the bandwidth for data transfer through smartphones is increasing the visitor can connect directly to the server.

Concerning future developments of this system, we are thinking about the integration of videos. The videos would enrich the comments. This would also make the visit more interactive. Such integration would be easily developed using the <video> element of HTML 5.

Another possibility could be an audio-based navigation to make the system totally hand-free. Also, as we are able to track the visitor during their tour in the exhibition, it would be easy to set up an interactive map showing the busiest routes. This would be of interest for business purpose, for example to decide where to install gift shops.

It seems also quite reasonable to imagine the development of Augmented Reality Applications due to new features of HTML 5:

- the <canvas> element for 2D drawing,
- the <video> and the <audio> elements for media playback,
- support for local storage and local database,
- easy access to smartphone camera and audio,

Another promising approach lies in communicating objects (i.e. the Internet of Things). Some authors have already started working on this topic [32] [33]. Objects could be linked to paintings, artworks, etc. Objects could be implemented on credit-card-sized Linux computer such as BeagleBone. The content that should be delivered to visitors could be located at the object level. They could deliver information to visitors by means of Near Field Communication (NFC), Radio-frequency identification (RFID) or WiFi network.

Objects would be able to recognize visitors: age, preferred language, main interests etc. and then deliver to the visitor a content that should correspond to their profile. The exhibition would be like a sort of ubiquitous environment.

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