Paper

QRouteMe: A Multichannel Information System to Ensure Rich User-Experiences in Exhibits and Museums

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Abstract—In this article the QRouteMe system is presented. QRouteMe is a multichannel information system built to ensure rich user experiences in exhibits and museums. The system starts from basic information about a particular exhibit or museum while delivering a wide user experience based on different distribution channels. The organization of the systems' components allow to build different solutions that can be simultaneously delivered on different media. A wide range of media from touch-screen installations to portable devices like smartphones have been used. The used devices can communicate each others to increase the usability and the user experience for the visitors. Another important feature of the system is the definition of an inexpensive auto-localization system based on fiduciary marks distributed all around the building. In this article the system is presented from an architectural and functional point of view. A case study and analysis of experimental results are also provided in a real environment where the system was deployed.

Keywords—Exhibition, Integration, Multichannel information system, User-experience, Museums, Personalization.

1. Introduction

QRouteMe is an information system built to provide rich user-experienced for users attending museums or exhibits. The system infrastructure is organized in a modular way and the deploy is multichannel. The definition of an information system involves different research aspects starting from the methodology choices that have to be sustained. The modularization of the system is a direct consequence of the methodology chosen. At the top level is important to define the interaction process between the users and the system. The definition of a good user experience which is basically the interaction process starts from the analysis of the users' needs. Another important aspect is the goal of the system. This goal is described as a set of product objectives.

According to this objectives the contents are organized. The definition of a proper user experience starts from the definition of the typical classes of users for the information system. To classify the users a set of parameters are explicitly defined and, accordingly to a proper configuration, a set of models of typical categories. This classification process is often performed off-line as a prerequisite of the information system. Many classifications have been proposed. Falks [1] proposes five different categories of users: explorers, facilitators, experience seekers, professional/hobbyist, and rechargers. The personal context of the user includes aspects such as prior knowledge and specific interests, the physical context of the exhibit and the socio-cultural context related to inter and between group interactions. In [2] a simple taxonomy of the possible models is presented. To define users' models can be organized auto-evaluation tests or other support materials so the model can be implicit or explicit.

The definition of a complex information systems for museums and exhibits involves three main research areas. The first is related to contents organization: the proper content organization for the system is a knowledge definition problem. Different approaches can be used to perform the tasks related to content organization. The second research area is user modeling: the definition of a user model is a multidisciplinary research field and involves aspects related to the organization of relevant information to classify users. Another related aspect is the localization and tracking problem in an indoor environment. The user position and his movements inside the building are crucial information to define the class of the users. The third aspect is strictly related to contents fruition and user experience definition: the way and the media used in the fruition of the user experience are related to human computer interaction and his aspects. This paper addresses some of the presented aspects in this introduction. The architectural and functional solutions adopted led to the QRouteMe system. QRouteMe is a complex, multichannel information system to build and deliver rich user-experiences in museums and exhibits.

The system is able to personalize contents and to delivery them in different types of media. We use both stationary (totem/kiosk) media handlers based on surface computing to allow users a simple gesture-based interaction process, and mobile (smartphones, tablet) ones to allow adaptation in contents fruition. The purpose is to build a more personalized user experience. An important characteristic of the system is his adaptivity. The system is able to adjust the presentation of information and the user representation.

This is a key feature for systems that present limitations related to technical resources such as screen sizes, battery consumption, ergonomics, connectivity and limitations related to the user interaction process like haptic capabilities, working memory or even simply limited amount of time for a visit. The aspect of contents organization related to adaptation has been observed in several related studies.

A first important classification is presented in [3] where essentially three types of adaptive strategies are described. The first, defined as "adapted strategy", induces pre-optimization of contents and resources from the awareness of limitations.

The second type is an "adaptive strategy", where the system reacts to external changes in a sort of parameterized way and "adapting strategies" where is possible to handle different strategies according to environmental inputs. The adopted solutions for the QRouteMe system are essentially of the second type. We have observed of a series of environmental limitations and produced a set of strategies related to each of the initial constraints. A typical example is the visualization of information in smartphones with different screens. The produced output is able to adjust the contents organization according to screen size without any additional processing.

Another important feature in terms of adaptation is related to positioning process. In particular, the system is able to determine the user's position inside an indoor environment by means of fiduciary posts or interaction at kiosk location. Current smartphones localization system such GPS (Global Positioning System) have a resolution for indoor environments that is approximatively of 10 m. This precision is clearly inadequate in many situations, such as fairs and museum exhibits where a considerable amount of information can be located in a 10 m radius.

An important achievement for our system is related to his low-level deployment cost. The produced system doesn't need an expensive infrastructure to produce a rich user experience. The infrastructure organization is a typical client-server solution where one of more servers performs the tasks related to organization information and communication between the users and the system and a set of stationary media serving points connected to servers show information. A wireless network allow users' mobile devices to exchange information and to connect the client side to servers. To locate users no other sensor/actuator devices are needed. We are focused mostly on the interaction process. To such purpose the utilization of new technologies, such as surface computing used to develop more intuitive gesture-based interfaces have been proven to be effective.

In addition to this, the increased computing capacity of current portable devices shifts some of the computational load to the client side of the system. A significative plus aspect is the possibility to constantly interact with everyday life devices that can collect large amount of information to be used in personalized systems. Also the integration between devices with different connection capabilities is a technological key aspect able to allow different levels of fruition.

The rest of the paper is arranged as follows: next section reports related works. The third section of the paper depicts the system infrastructure. The fourth section presents the first implemented use case and the related experimental results. The paper ends with conclusions and future works.

2. Related Works

The definition of systems able to support users in indoor environments like an exhibit or a museum is an active and multidisciplinary research field with different research areas. As stated the main aspects are related to the process of contents definition and organization, to personalization for different users. In addition to this, many related problems have been investigated such as the localization of users for indoor environments.

One of the first works in this field is the Cyberguide project [4]. The main purpose was the definition of a set of different prototypes both for indoor and outdoor guides designed as a combination of four main components: a cartographer component including the map (or maps) of the physical environments, a librarian component, the information repository containing all the information to be presented, a navigator component used to keep track of the users' positions in the environment and a messenger component used to record and exchange messages to/from users and the system.

Other relevant systems are the Hippie/HIPS project [5] that is focused on development of an exhibition guide, providing guidance and information services. From the observations about the visitor's movements through the exhibition the systems creates a user profile and suggests other interesting exhibits or paths inside the current exhibits.

The TellMaris [6] system is an example of a mobile tourist guide developed combining both two and three-dimensional graphics running in a mobile phone. The possibility to automatically define related information for a guide has been exploited in many projects such as the PEACH project [7] where the generation of some position related contents and post-visit reports are automatically performed. The CHIP project [8] tries to combine different semantic web techniques to provide personalized access to digital museum collections both online and in the physical museum. Most of the works in this area are focused on an explicit definition of a knowledge base while some works tries to implicitly define a user model. The user model definition is mostly based on statistical models rather than recommendation techniques [9].

Another point of view to build a museum guide is to target not just a single user but a group visiting a museum. The Sotto-voce [10] system is designed specifically with this goal providing a communication mechanism to support interaction. From an architectural organization a complex system able to produce and adapt contents for different media has been organized mainly as a client server architec-

ture or as a multi-agent system. The drawbacks of the two approaches are well known. In the first case the server machine is obviously a point of failure and also the communication through the network can be critical while an explicit message passing mechanism has to be implemented for an agent based system together with a knowledge base used to define the communication ontology for the agents.
According to users' localization there are essentially two types of location technologies: the indoor positioning and the outdoor positioning. The second class of problems has been solved using satellite infrastructure with GPS. The reached level of accuracy is in the order of some meters and is generally a good accuracy for outdoor-based information applications. The indoor location suffers of the degrading reception of GPS-based systems. Furthermore the accuracy is not so important while in many cases the users needs a system able to recognize boundaries and able to positioning a person through a symbolic location (e.g., "in the main hall" or in "the first room"). Several methods have been proposed to solve the problem using different media like infrared beacons [11], [12] or radio signals from wireless LAN [13], [14], RFID technology [15] or cameras and microphones [16] to detect user location.
One of the main drawbacks of the proposed approaches is related to the initial cost to organize a large-scale event like an exhibit. Another way to achieve the same functionality is through the detection of the position by comparison between a set of floorplans and an image taken from the cell-phone camera [17]. This method has a major disadvantage because it requires all the floorplans for a particular building to be known in advance.
All the proposed methods require an electronic infrastructure to facilitate measurements with all the necessary sensor/actuator devices. In this case a good compromise in a costs/benefits tradeoff can be an approach able to give to users not continuous information of their position but discrete information.
We are looking to provide an inexpensive, building-wide infrastructure to be used in a large-scale type of events with a number of users that can be measured in thousands of people. So the utilization of a fiduciary marker able to be easily recognized from users is a natural solution for this type of problems. In this way the user localization shifts from a continuous to a discrete problem. Some similar approaches have been recently used to solve this problem. In [18] a system used as a location-based conference guide called Signpost is presented. The system works only with Windows mobile phones but it can be used in large-scale events with no further costs due to other equipment.

3. System Infrastructure Definition

The main goal of the QRouteMe system is to provide users with domain information, according to their actual need and to the context they are currently part of. To this end, we decided to design the system infrastructure according to the client-server paradigm. This choice allowed us to obtain an easy-to-implement, easy-to-scale and easy-to-manage framework of components, which can be suitably used to reach our intended goal. The QRouteMe infrastructure is composed of three main components:

– QRouteMe Platform,

– QRouteMe Front End,

– QRouteMe On Site.

The first one operates at the server side, whereas the second and third components operate at the client side. Figure 1 shows the three main components, their modules and the overall data flow among them. In the following sub-sections we will give an overview of each component.

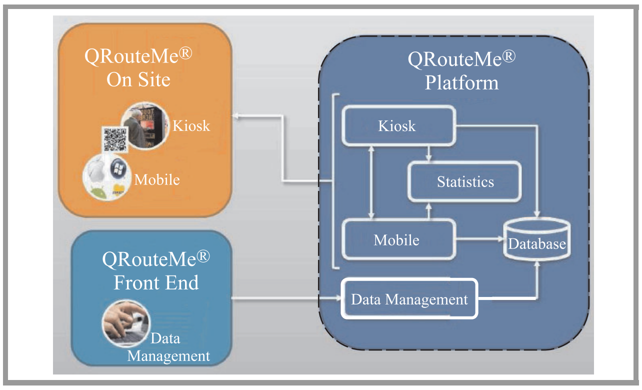

Fig. 1. QRouteMe infrastructure definition and data flow diagram.

3.1. QRouteMe Platform

On the server side, the QRouteMe Platform component main activities are data related: management, processing and storage. This component carries out most of the processing tasks of the whole system, and it is composed by four different modules (see Fig. 1):

– Kiosk,

– Mobile,

– Statistics,

– Data Management.

All of them interact, whether directly or not, with a database based on the relational model. Its schema has been defined in order to be easily adapted to the changing data domains and to the kind of service users have to be provided with. The data set views are generated using a server side scripting language, so they can be suitably and quickly adapted to the customer requirements in terms of data presentation. The database can also be populated by the client himself, using the QRouteMe Front End component. This feature gives the customer the possibility to keep the system up-to-date at any time, and to keep the full control on data integrity and correctness (these are critical properties, especially at the deployment time). The Kiosk and the mobile modules manage the users' requests according to the device they are actually using. These modules extract the useful data from the database, and compose the consequent information taking into account which channel the user is currently using to interact with the system. The Statistics module traces the users as they surf the information whilst completely preserving their anonymity and protecting their privacy. By monitoring a great number of parameters, it can provide administrators with a wide range of useful information about the user behavior. Customers may know how many users accessed the application, which and how many pages they were viewing, and so on, according to their feedback needs. This way, they could fine tune the interaction to improve the final user experience, or simply they could evaluate the system effectiveness. Of course, the information provided by the module can go through different levels of detail. It can carry on the overall system evaluation, the separate kiosk and mobile evaluation, or the evaluation of each device involved in the interaction. The Data Management module handles the interaction between the Platform component and the applications running on the Front End component.

3.2. QRouteMe Front End

The QRouteMe Front End component consists of ad-hoc tools made available to the customer and implemented according to his needs. The main goal of these tools is to allow the customer to create, read, update and delete data, either directly or by giving data owners the possibility to do it by themselves. This component interacts directly with the Data Management module within the Platform component (see Fig. 1). This ensures that all its activities can be carried out by keeping data integrity and correctness, while avoiding possible conflicts. Furthermore this component improve the system adaptability to the application domain changes, as well as the preservation of data privacy, making possible to avoid the intervention of personnel not related to the customer (such as technicians).

3.3. QRouteMe On Site

The QRouteMe On Site component provides the end users with the information suitably composed by the Platform component (actually by its Kiosk and Mobile modules, see Fig. 1). It represents the system interface with the users. This component consists of a set of applications which can be made to work together in different ways according to the customer needs. The QRouteMe On Site component allows people to access the available information by means of kiosks suitably configured, or by their personal mobile devices. Concerning the mobile devices in particular, applications can be natively designed and implemented for the most common operating systems (Android, iOS, Windows Mobile and Symbian), thus exploiting all software and hardware features. Nevertheless, if there is no need to use specific hardware features (such as accelerometers, cameras, positioning systems), a cross-platform web-based solution can be used, in order to have a better portability and a faster development. This component also links both kiosk- and mobile-based information access ways by means of QR codes (Quick Response) [19]. People can search for information on a kiosk and then transfer the desired output on their mobile, or people can directly access pieces of information by shooting at QR codes, provided that their mobile device is equipped with a QR reader.

4. Case Study

4.1. Deployment Event

QRouteMe has been implemented for the first time at the Vinitaly 2011, the largest fair dedicated to the Italian wine industry, which takes place every year in Verona (Italy) in April. It is organized by Verona Fiere that is responsible for all the logistic tasks. Our customer was the Istituto Regionale della Vite e del Vino (IRVV, Sicilian Institute of Vine and Wine), who asked us to implement an information system inside the "Sicilia" pavilion within the fair. This allows us to have a great number of information coming from a unique source. This is the most common case for exhibits and museums. The main goals of the system, as requested by IRVV, were:

- allow visitors to access information about Sicilian wine producers, even in mobility,
- help them moving around the pavilion with a localization system,
- obtain the list of services visitors usually look for (help-desk, secretary).

4.2. QRouteMe Layout at Vinitaly 2011

After the study of the location and of the booth layout, we decided that the optimal deployment of our system could be as follows:

- 14 fixed touch totems (InformaPoint),
- 2 web and database servers for redundancy,
- 1 wired LAN (designed by us and implemented by Verona Fiere),
- 1 wireless LAN with controlled access (designed by us and implemented by Verona Fiere),
- 1 database to store producers data, the booth layout, and other additional data;
- 1 app for mobile users of iOS-based devices (iPhone, iPod, iPad),
- web-based presentation of information for mobile users with other operating systems,

- 234 QR codes for the quick access to contextualized information.

Figure 2 shows the position of the fourteen touch-screen totems in the pavilion. The kiosk position was decided based on surface area and previous event knowledge about visitor entrance patterns to maximize the usage. The triangles in Fig. 2 represent the ways of access to the pavilion, whereas the placeholders "i" show the points where the fourteen touch totems InformaPoint were placed. Kiosk covered an average surface area of about 500 m^2, with higher concentration around the main entrance (at the lower left corner) and along the left side, closest to neighboring pavilions, where they could be easily accessed by visitors upon entering the pavilion. The overview of the installation setup is shown in Fig. 3.

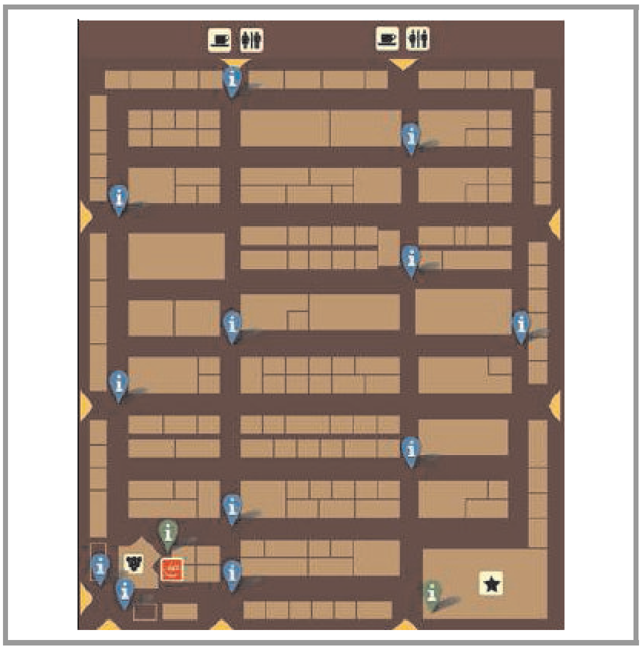

Fig. 2. Kiosks layout within the pavillion.

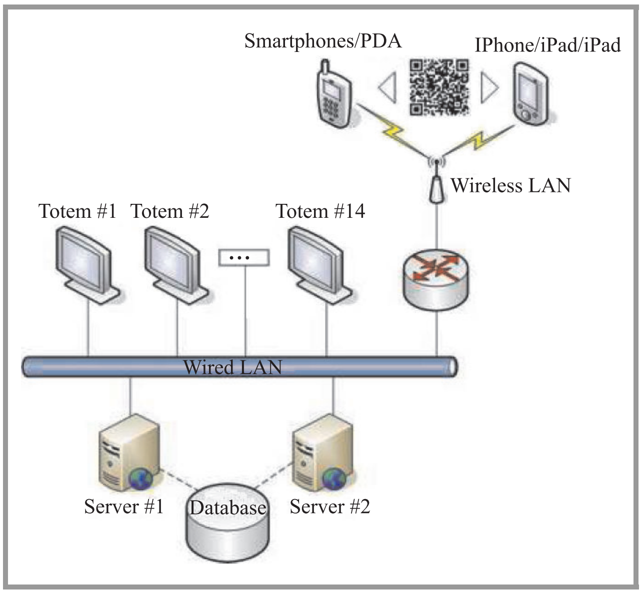

Fig. 3. QRouteMe installation setup.

4.3. Information Provided by QRouteMe

According to the IRVV needs and requirements, the QRouteMe system deployed at Vinitaly 2011 provided visitors with information about:

- Producers list, with alphabetical and direct search features, and related details:
  - producer information,
  - wine of the year for each producer,
  - list of produced wines for each producer,
  - QR code to quick access producer's information (audio, video, information forms),
  - producers booth position within the pavilion.
- Wine areas and related details:
  - area description and pictures,
  - producers belonging to a given vine area.
- Information about the IRVV.
- Information about services available within the pavilion.
- Information about the system.

The information were available both in Italian and English. Visitors equipped with a smartphone could access the system by means of their devices, exploiting the self-positioning feature based on the use of QR codes. They could see their current position within the pavilion, could access directly to information about the producer they were looking at, and could see the shortest path to reach a given producer's booth from their current position. Besides this, users of iOS-based devices could download an application (http://itunes.apple.com/it/app/sicilia-vinitaly-2011/id427870112?mt=8) that allow them to navigate a 3D model of the pavilion, to contact a producer via phone or email, and to share their own experience on the most common social networks.

This application includes a software module capable of decoding QR codes and interpret them correctly, according to the type of information that they contain. In addition to that, was developed a module capable of locating the visitor without using geo-referencing systems. In order to identify its location, the system asks the user to photograph a QR code. The decoded string indicates uniquely the position that photographed QR takes on the map (see Fig. 4), which coincides with that of the visitor who stands before it. Furthermore, this position can be used by the visitor as a starting point for generating a path to another point of interest.

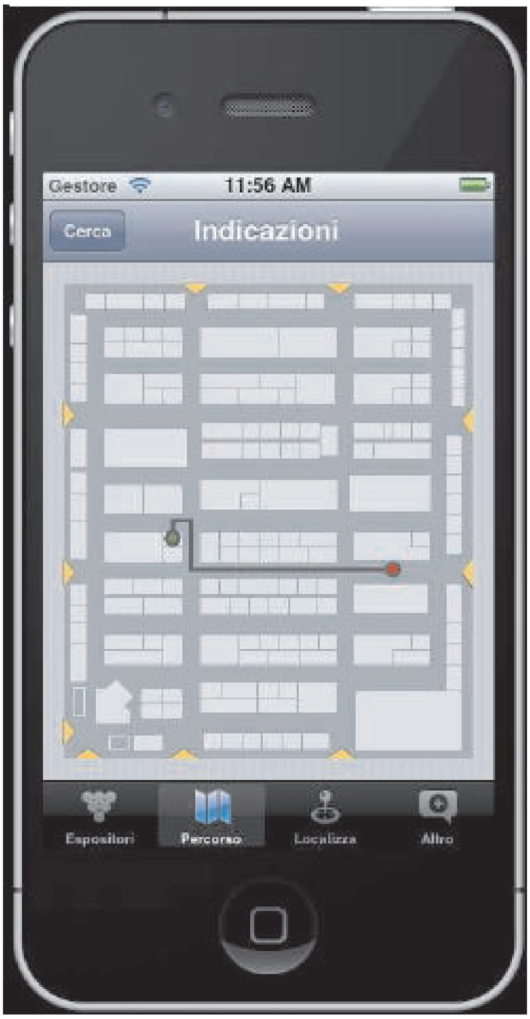

Fig. 4. Path displayed in the iOS application for Vinitaly 2011.

5. System Usage Reports and Considerations

QRouteMe has been developed to allow friendly and intuitive interaction with the user. To this end the fourteen InformaPoints were equipped with a GUI designed only for touch-based interaction that proved to be very effective, and easily understood by users. The QRouteMe system was deployed at the Vinitaly 2011 international wine fair, held in Verona (Italy) from 7 to 11 April 2011. It worked for five days, during opening hours (about ten hours a day). This proved to be a good test bed for our system, both for its effectiveness and for its robustness against any kind of human or technical fault. The whole fair counted 8 big pavilions of about 8,000 m^2 each (72,000 ft^2), with a total count of more than 150.000 visitors from all over the world, either business operators or tourists. The system was actually deployed inside the "Sicilia" pavilion, one of the largest pavilions within the fair. During the working hours, we observed the behavior of people while interacting with totems, taking into account comments and observations. At the first day of the fair, we observed that the main goal of people was to single out a given wine producer from the available alphabetical list. This task was at first carried out by means of a vertical scrolling bar, with the aid of an alphabetical index allowing for the fast scrolling to the corresponding letter. Despite this possibility, we saw that that task was not so easy to accomplish, mainly due to the length of the list (more than 220 producers). We then decided to test the modularity of our system, by adding an interaction way while the system was up and running. In fact, we set up the on-screen keyboard direct search feature actually modifying the Kiosk module within the Platform component (see Fig. 1 for reference), with no need to interrupt the service operation.

Once deployed, the direct search by means of the superimposed on-screen keyboard became one of the features people found most useful during their interaction with totems This feature allowed them to easily find their preferred producer, its location within the pavilion, the path to reach it from the current position and the list of produced wines. During our survey, we observed that users experienced no other particular difficulty while interacting with the system. Once facing a totem, users started to interact with it in a few touches, independently of age and without any previous training. This is directly related to familiarity that users have with GUIs and gesture based interaction. Starting from the second fair day, we observed growing queues of people in front of totems, thus confirming the effectiveness of the interaction model and of the totem layout within the pavilion.

Fig. 5. People waiting for InformaPoint usage

Our informal observations about QRouteMe usage by InformaPoint totems were confirmed by the final reports generated by the system, with more than 40,000 accesses to the pages, and more than 13,000 accesses to the producers' pages. Table 1 shows a short resume of those reports both for the Italian and English version of pages.

Concerning the interaction from mobile devices, of course we could not observe the behavior of people while using their devices to access the system. We can only shortly discuss the reports resumed in Table 2 taken from the Statistics module of the system.

Table 1
QRouteMe usage report (totems)

Date	Single P.		Producer P.	
	Italian	English	Italian	English
07/04/11	4987	688	1480	180
08/04/11	8019	1063	2867	366
09/04/11	11469	945	4091	307
10/04/11	8379	529	2793	187
11/04/11	4146	122	1402	42
Subtotal	37000	3347	12642	1082
Total		40347		13724

Table 2
Mobile devices usage report

Data	Single page access
07/04/11	813
08/04/11	810
09/04/11	626
10/04/11	427
11/04/11	172
Total	2848

The number of total accesses to single pages is low if compared to that obtained by totem (with a ratio of about one to fifteen), due to different reasons:

- totems were well placed all around the pavilion, so that users could easily see them,
- totem places were clearly indicated with big banners hanging from the pavilion ceiling,
- there were no equivalently visible signs about the possibility to access the system by means of mobile devices,
- people who knew about the mobile access found anyway easier to use totems, instead of registering to the wireless network, download the app, install it, and finally use it.

For those users who did access the system via mobile devices (and available to fill a short satisfaction report), the level of satisfaction was rather high, as despite a small overhead, the application offered more contextualized information, practically out of your pocket, quoting one of those users.

6. Conclusions and Future Works

In this works QRouteMe has been presented. QRouteMe is a multichannel information system able to build and deliver rich user experiences in exhibits and museums. The overall system infrastructure and an instance, deployed in a large exhibit, were presented. The system presents several advantages starting from low deployment costs for very large environments. In the QRouteMe the user localization is approached as a discrete problem using a set of fiduciary markers that are able to auto-locate the users. The system architecture is built as a modular set of components that are chosen and selectively deployed according to the specific needs of the application, without any loss of effectiveness. Current works aims at implementing customizable front-end for final customers to allow for complete contents organizations and easiness of user experience and a more complete statistic component.

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