ARCHAEOAPP ROME EDITION (AARE) – MAKING INVISIBLE SITES VISIBLE

e-Business Aspects of Historic Knowledge Discovery via Mobile devices

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Abstract: Rome is visited by 7 to 10 million tourists per year, many of them interested in historical sites. Most sites that are described in tourist guides (printed or online) are archaeological sites; we can call them visible archaeological sites. Unfortunately, even visible archaeological sites in Rome are barely marked – and invisible sites are completely ignored. In this paper, we present the ArchaeoApp Rome Edition (AARE). The novelty is not just to mark the important, visible, barely known sites, but to mark the invisible sites, consequently introducing a completely novel type of site to the tourist guidance: historical invisible sites. One challenge is to get to reliable, historic information on demand. A possible approach is to retrieve the information from Wikipedia directly. The second challenge is that most of the end users have no Web-access due to the high roaming costs. The third challenge is to address a balance between the best platform available and the most used platform. For e-Business purposes, it is of course necessary to support the highest possible amount of various mobile platforms (Android, iOS and Windows Phone). The advantages of AARE include: no roaming costs, data update on demand (when connected to Wi-Fi, e.g. at a hotel, at a public hotspot, etc. ... for free), automatic nearby notification of invisible sites (markers) with a Visual-Auditory-Tactile technique to make invisible sites visible.

1 INTRODUCTION

1.1 Motivation for research

Most sites that are described in tourist guides (printed or online) are archaeological sites; we can call them visible archaeological sites. Unfortunately, even visible archaeological sites in Rome are barely marked – and invisible sites are completely ignored. The novelty of the ArchaeoApp Rome Edition (AARE) is not just to mark the important visible but barley known sites, but to mark the invisible sites, consequently introduces a completely novel type of site to the tourist guidance: historical invisible sites.

Moreover, AARE provides two modes: standard tourist mode and a scavenger hunt modus, where it makes use of powerful game-based learning concepts (Mayo, 2009), (Hoffmann, 2009). This is definitely an issue of e-Business since, according to Marca et al. (2012), e-Business needs to cope with the behaviour and requirements of Digital Natives (Prensky, 2001), which is the generation growing up with the Internet and having a great degree of competence concerning the usage of mobile Web services.

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Consequently, digital natives are well informed and assertive regarding products they want to buy (Marca et al., 2012).

It is important to first understand the difference between archaeological sites and historical sites. The subject of Archaeology is to find and document material of ancient cultures, including buildings, houses, weapons, tools and even stuff that ancient people threw away. However, the subject of History is a different issue, namely the analysis of events and actions. For that, historical sites are invisible because they are one-dimensional. They only exist in the fourth dimension, similar to an interface in a Harris matrix (Harris, 1979). However, historical sites are attached to special places.

A good example is the battle at the Milvian Bridge (Speidel, 1986). This was the final battle between the two rivals Maxentius and Constantine in October of the year 312 AD. This battle is not only significant as the start of the Constantinian Dynasty, but can in some way also be seen as the beginning of the rise of Christianity, for Constantine was the first Emperor to equate Christianity completely with the pagan religion. Interesting for us is that this battle was a historical event with no archaeological evidence left. However, there are reports of roman writers, which allow us to reconstruct the battle site – stretching from the town of Prima Porta to the name giving bridge in Rome. Another brilliant example is the route of the roman triumph, a circle line through the city; or sites of events, such as the murder of Julius Caesar, the murder of Tiberius Gracchus, the site where the ritual declaration of war took place. Our basic idea is to raise awareness for such historical sites by marking them with coordinates and to create a mobile application, which alerts an interested visitor when reaching such a site. Consequently, we built on previous work (Holzinger et al., 2011a), (Holzinger et al., 2011b) and designed, developed, implemented and tested a so-called ArchaeoApp Rome Edition (AARE). According to Marca et al. (2012) e-Business needs to cope with the behavior and requirements of "digital natives." The generation of the digital natives grew up with the Internet and has a great degree of competence concerning the usage of Internet services. Digital natives are well informed and assertive regarding products they want to buy

1.2 Challenges and Approaches

The implementation of the AARE idea is not trivial and there are several different approaches for a solution.

(1) The first challenge is related to information retrieval: How to bring the historical content to the mobile device on site. One possibility is that experts in classics prepare special content and put it on a Web server, which can be accessed from the mobile device on demand. The more charming possibility is to make use of already existing content on Wikipedia and, since it is an open site, that experts in classics provide special content in Wikipedia directly. The challenge is to crawl through the existing sources and to retrieve relevant data for display on the mobile device on site.

(2) This brings us immediately to the second challenge: In commercial mobile telephone networks, the call setup to an international roaming subscriber is always routed through the home network of the subscriber, which results in the usage of two expensive international telephone trunks. Apart from some technical solutions (Sardag, 2011), (Yi-Bing et al., 2011), mostly, the tourists just disable their Internet access. Our solution is to make use of existing wireless access points as they are available mostly in hotels, public places, or restaurants (e.g. McDonalds).

(3) The third challenge is not less challenging: Tourists have a variety of mobile devices. Based on Gartner's report for the 4th quarter in 2011, there was an evident Android dominance (50.9%) of the world-wide smartphone sales. The iOS ranked second with 23.8% of sales, Symbian third (11.7%) and Black Berry forth (8.8%). The truth is that Android is growing faster due to the diversity of manufacturers.Moreover, the AARE can be adapted to two different levels: Standard Guiding Modus, and Scavenger Hunt Play Modus; which brings us to the fourth challenge.

(4) In our previous work, we made good experiences with scavenger hunts (Holzinger et al., 2011b), borrowing powerful concepts from game-based learning – which, together with mobile technologies offers enormous potential in the future, especially from an e-Business perspective (Bulander, 2010). It can be used for both educational and play purposes. Essential elements of this play (timed task, teamwork, mobility) can be used for a collaborative problem-solving approach; such team based learning was early recognized as important (Hutchings et al., 1993): End-users are confronted with a problem, which is usually more easily solved by the collective intelligence of the whole group (Massimi, Ganoe & Carroll, 2007). Collective Intelligence is currently of high interest among researchers, due to the fact that there are effects regarding the performance of individuals on a wide

variety of cognitive tasks (Woolley et al., 2010). Recent research showed that different collaboration models, strategies, as well as atmospheres could greatly influence the performances of its members. In collaboration, each individual can have better learning effectiveness (Shih et al., 2010).

2 BACKGROUND

2.1 Milvian Bridge – historical landmark for Christianity

We explain AARE on a first practical example: Assume you are a historically interested visitor of Rome. Assume you are just approaching the Milvian Bridge (Figure 1). AARE automatically detects that there was a historic event, because it checks automatically for the coordinates from Wikipedia (Figure 2) and retrieves it, because the coordinates have been marked by a qualified historical and/or archaeological expert as a so-called "invisible site". The end user is then reminded by vibration, visual, or acoustic signal that she/he is in range of an invisible site. Now the information will be displayed directly on the smartphone (Figure 2).

Figure 1: The Milvian Bridge, as the visitor sees it today (image taken from Wikipedia: http://en.wikipedia.org/wiki/Battle_of_the_Milvian_Bridge)

The Milvian Bridge is located 41° 56' 7.8'' N, 12° 28' 1.1'' E.

The battle of the Milvian Bridge was a significant event in late antiquity, because it was the event that ended the war between Constantine and Maxentius. Constantine was victorious, after he had drawn the Christian symbol Chi Rho on his shields, as commanded in a vision he had. Although Constantine himself probably was no Christian, he sympathized with Christianity and stood at the beginning of its upraise.

Figure 2: Structured Information to the Battle of the Milvian Bridge from Wikipedia (see link below Figure 1)

2.2 Theatre of Pompey – the site of Caesars Murder

As further nice example for an invisible site we present the Theatre of Pompey (Claridge, 2010) – where it is not visible that here Caesar died. In Figure 3, we clearly see that there is not much to see today on this classical site. The Theatre of Pompey is located at 41° 53' 43'' N, 12° 28' 25'' E.

The eastern end of this first century BC building, is today located beneath the Via di Torre Argentinia. In ancient times, there was an annex where Senate meetings where held, further this is the very site Julius Caesar was murdered on 15th March 44 BC.

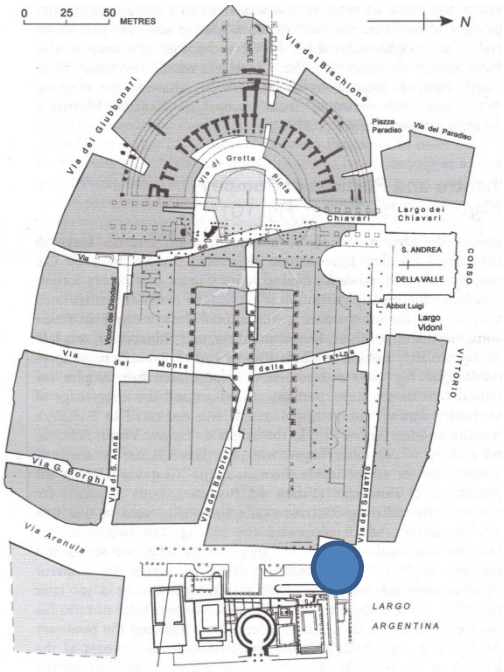

Figure 3: The archaeological site: The Theatre and Porticus of Pompey as described in the Oxford archaeological guide, the blue spot marking the murder of Caesar (Claridge, 2010)

The blue dot in Figure 3 marks the location Caesars murder took place. It was at the eastern end of the building, which once contained an annex where Senate meetings were sometimes held. Today, it lies under the Via di Torre Argentinia (Figure 4).

Figure 4: The visible site: To the beholder it is not clear that A was the location of the murder of Caesar (Image taken from Googlemaps);

For more information on Curia, assassination of Caesar: http://en.wikipedia.org/wiki/Theatre_of_Pompey

2.3 Selected Points of interest

Here some points of interests as further examples:

- Domus Aurea 41° 53’ 29’’ N, 12° 29’ 43’’ E

This was the private house of Nero, which he intended to build within the City of Rome. It was never fully completed, because it was destroyed shortly after Nero committed suicide. The fact that this is a type of building not supposed to be built in the centre of a city is the main cause why the people of Rome hated Nero.

- Temple of Bellona 41.89’ 24’’N, 12.4799° E

In roman times it was important to justify a war in front of the gods and declare it a bellum iustum. Very important was the ceremony of war declaration; the ritual throwing of a wooden spear across the enemy border to confirm the war. With the expansion of the Roman Empire one was forced to create a symbolic enemy territory within the city of Rome.

- Circus Maximus 41° 53’ 10’’ N, 12° 29’ 9’’ E

It was probably the biggest arena of all times; although the details on the capacity vary between 300,000 and 500,000 spectators. Throughout its almost 1000 years of existence the Circus Maximus was the site of countless historic events, the most drastic probably would be the great fire of Rome, which had its origin within one of the shops located in the Circus.

- Solarium Augusti 41° 54’ 11.38’’ N 12° 28’ 42.75’’ E

8This was the largest ancient sundial. It consisted of a 30 meter high Egyptian Obelisk that Augustus had erected in 10 BC, at the twentieth anniversary of the conquest of Egypt. This solar meridian was designed by the mathematician Facundus Novius. Its purpose was to demonstrate the accuracy of the new calendar, which had already been introduced by Julius Caesar.

- Ara Pacis 41° 54’ 23’’ N, 12° 28’ 32’’ E

This Altar is the most famous example for Augustan monumental sculpture in Rome. It was decreed by the Senate on 4 July 13 BC to celebrate Augustus’ return after three years’ absence in Spain and Gaul. Today the Altar is not at his original location but in a separate museum. Originally it was on axis with the great obelisk of Augustus solar meridian.

Very interesting is the Route of Triumph (see Figure 5), consisting of the following POIs – used of the AARE Scavenger hunt:

- Campus Martius 41° 53’ 52’’ N, 12° 28’ 38’’ E
- Circus Flaminius 41°53’ 34’’N, 12°28’ 39’’ E
- Forum Boarium 41° 53‘ 20‘‘ N, 12° 28‘ 52‘‘ E
- Circus Maximus 41° 53’ 10’’ N, 12° 29’ 9’’ E
- Forum Romanum 41° 53’ 31’’ N, 12° 29’ 12’’ E
- Kapitol (Rom) 41° 53’ 36’’ N, 12° 28’ 58’’ E

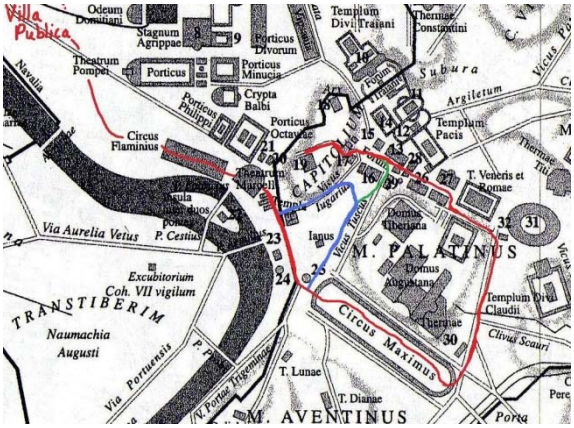

Figure 5: The route of the triumph processing for our Scavenger hunt game (Image from (MIT, 2012))

3 SYSTEM ARCHITECTURE

According to a recent Gartner study (www.gartner.com/it/page.jsp?id=1622614) Android will command nearly half of the worldwide smartphone operating system market by the end 2012. They predict that Apple’s iOS will remain the second biggest platform worldwide through 2014. Based on these predictions, we decided on the Android platform, rather than the one used for the previous ArcheoApp (Holzinger et al., 2011a), (Holzinger et al., 2011b). There are two mode types available in the AARE: *tourists* and *scavenger hunt*. Both types include similar features; the difference is in how the invisible sites or hints are shown.

3.1 Features overview

The use of GPS has few disadvantages s.a. potential failures (battery consumption) and ambiguity (atmospheric conditions or buildings may prevent accuracy); however the biggest advantage from the business perspective is that it works at no cost.

There are two types of modes available in the AARE as mentioned before:

(a) Standard Guiding Modus and
(b) Scavenger Hunt Play Modus,

both modes include similar features; the difference is in how the invisible sites or hints are shown.

Table 1: Feature comparison of modes in AARE

	Tourists	Scavenger Hunt
Map view	✓	✓
My location	✓	✓
All invisible sites	✓	
Next hint		✓
Notification channels	✓	✓
Discovery radius	✓	
Multilanguage	✓	✓
Help	✓	✓

After the mode type has been selected, a map view is shown to the user. The map view is based on the Mapsforge (Mapsforge, 2012) toolbox for fast on-device rendering of OpenStreetMaps data on the Android platform. It is released under the free and open source LGPL3 license.

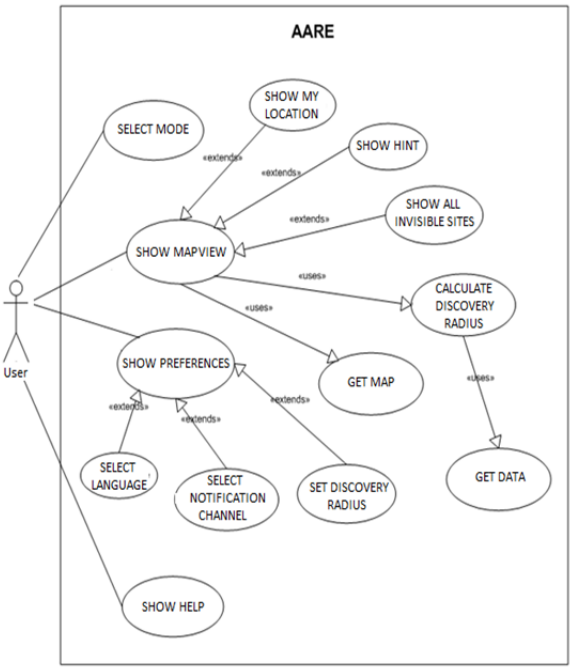

Figure 6: Use case diagram of AARE application

Users can select their preferable language in the preference area, which consequently affects the notification channels (visual & audio). Moreover, they can set the discovery distance (radius) of invisible sites. A function for calculating the discovery radius checks against the data and shows dynamically invisible sites on the map view.

In tourists mode users have an option to see available invisible sites; however this features is omitted in the Scavenger Hunt where users can invoke the next hint button instead. The users get an instructional description by invoking the help button.

3.2 Data structure

All data (images, content and maps) are stored externally on the Secure Digital (SD) card.

The descriptors of invisible sites are defined as XML files and are structured as following:

- id (type: long) – unique identifier
- mode (type: text) – tourists or scavenger hunt
- language (type: text) – language of the text
- description (type: text) – description of the invisible site
- image (type: text) – name of the image
- latitude (type:) - latitude coordinate
- longitude (type: numeric) - longitude coordinate

In this way, a higher flexibility for further releases was ensured (i.e. migrating to different data storage, size of file system and performance wise).

3.3 Data updates

A server-side Content Management System (CMS) for authoring invisible sites is used by authors (archeologists) who can create, edit, delete and update invisible sites online.

On the client-side, an update feature for retrieving the data from the server-side handles the synchronization process. When the AARE is installed on a mobile phone, the update is automatic.

This procedure is shown on Figure 7. First the AARE sends a request call to the server-side web address and checks if a new version is available (1). Next, a compressed package in a zip file format, containing XML files, images and a map is pulled down (2). At last the application unpacks the zip package locally and structures the content hierarchically (3). The hierarchy is based on folder, wherein each folder represents an invisible site.

The data update on demand comes very handy when travelling abroad. It lowers the costs since users can use free Wi-Fi connections, for example at a hotel or at public hotspots.

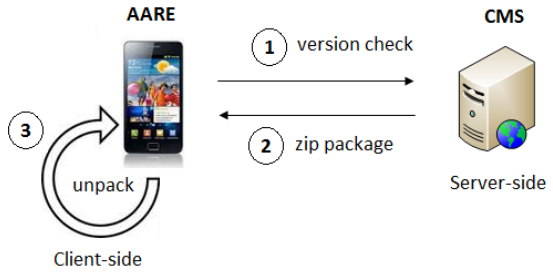

Figure 7: Procedure of data update in AARE

3.4 User mode: Tourist

Tourists can discover invisible archeological sites based on the GPS location. The AARE application first locates the user over GPS coordinates (gets the latitude and longitude values from device) and displays the user's location in a map view as shown in Figure 8.

However, the invisible sites (presented as red markers) are not visible immediately. Red markers on the map become visible when the distance between the user and the marker is inside the discovery radius, in our case the default value of the discovery radius is 500 meters but can be changed in preferences. When this happens, the user is notified.

Notifications and information delivery can be set in three ways, depending on the user's preferences:

(a) *Visual* - tapping the marker on the map shows an image with description of an invisible site
(b) *Auditory* - using the Android speech synthesis. The Text-to-Speech (TTS) capability notifies the nearest invisible site and read its description
(c) *Tactile* - vibration alerts to the next invisible site

The notification channels in the AARE represent a novel approach and reflect similar characteristics to Visual – Auditory – Kinesthetic – Tactile (VAKT) learning styles (Boyles & Contadino, 1998). In this way, the users can select their preferable notification channel according to their needs for the newly acquired information.

Figure 8: A view on the AARE - blue circle represents the user's GPS location, the red pin is the nearest invisible site which remains inside the discovery radius (500 m)

3.5 User mode: Scavenger Hunt

The *Scavenger Hunt* uses the GPS location to unlock further hints. The idea behind the *Scavenger Hunt* of AARE is based on the concept of shade (Ramachandran, 1988), revealing from the PC game franchise *Heroes of Might and Magic*.

The principle of the shading conceptuality can be seen in Figure 9, used originally in Warcraft I, II & III, which is the most subscribed online game, according to a paper from Science (Mayo, 2009). Such games have potential to dramatically change how people interact, navigate Web sites, and finally conduct business (Mennecke et al., 2007), (Petrova & Qu, 2007) so we took such examples very serious.

Figure 9: Shading conceptuality (Gamespot, 2002) – there is now no shading effect in World of Warcraft, since it uses now a different playing paradigm

The user in AARE discovers the map based on the first destination hint. There are no markers visible on the map at the start when the first hint is revealed (usually a text-based description but it can also be a picture); however when the user starts moving, the marker (next hint) becomes visible when the user is inside the discovery radius. The *Scavenger Hunt* requires a locked value of the discovery radius and cannot be changed by the user. This is a security precaution to prevent cheating.

4 E-BUSINESS ASPECTS

Similar to the ArchaeoApp (Holzinger et al., 2011b) AARE can bring several benefits:

On a Business-to-Consumer level (B2C) there is a mass market in tourist areas on a personal level, where people can download AARE for a small fee. In March 2012 Google announced the Google Play digital content service, which represents a unified marketplace for music, movies, books and applications. Purchases can be made by using the Google Wallet system (formerly known as Google Checkout) for simplifying the payment process.

On a Business-to-Business level (B2B), AARE can be interesting for a mass market in large towns with a historic background (e.g. Rome, which is a good example, due to its 7M+ visitors per year). However, we emphasize that this might be of equal interest for smaller towns, open-air museums or archaeological finding places. A good example is Carnuntum, formely in the Roman province of Pannonia (now Lower Austria), where only a few people know that it contains the largest Amphitheatre, outside the City of Rome.

It is proven that customer interactions can create opportunities for positive experiences leading to long-term relationship building (Rose, Hair & Clark, 2011). This can be especially relevant for tourism.

Moreover, by using AARE as an attractive customer benefit, the circle is closed by offering the big advantage of raising awareness for our cultural heritage – thus combining both aspects: e-education and e-business.

5 CONCLUSION

We tested AARE on a small scale and it worked well – real-world demonstration will be given in Rome. The novelty is in the automatic detection of an invisible site whilst avoiding roaming costs. The advantages of AARE are threefold:

First, it represents an automatic invisible site detection based on Visual-Auditory-Tactile (VAT) notification channels, where the origins can be found in Visual-Auditory-Kinaesthetic-Tactile (VAKT) learning styles. By using all three types of notification channels (description-speech-vibration), users have the ability to choose their preferable channel when receiving the information.

Second, the invisible sites (or hints in scavenger hunt mode) are revealed inside the discovery radius by using the shading concept. Based on the user's GPS location the discovery radius calculates dynamically the radial distance to nearest invisible site and notifies the user if the invisible site has been discovered. Furthermore, the shading concept gets especially useful for collaborative problem-solving assignments in scavenger hunt where users unlock next hints with their GPS location.

Third, the AARE uses GPS services in combination with offline maps, avoiding roaming costs. The users need to update the application before they travel or by using the wireless network to get the latest data. In the current version of AARE, the data are stored in the database manually using the SQLite Database Browser visual tool, which is used to administer database files compatible with SQLite; however this process will be replaced by a web-based administration. AARE serves also as a nice example for context awareness of m-Services, we follow the term context as originally introduced by (Schilit, Adams & Want, 1994), and the relevance for e-Business described in (Decker, Schiefer & Bulander, 2006).

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