EXPLOITING WIRELESS NETWORKS FOR VIRTUAL ARCHAEOLOGY: THE PAST PROJECT

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Under the IST 5th Framework Programme, the EU has funded PAST, a project aimed at exploiting wireless computer networks in archaeological fields, to improve the understanding of the general public of what is visible in an archaeological site.
Project participants include three archaeological sites, Bibracte in France, Toumba in Greece and Passo di Corvo in Italy; researchers of Computer Science and archaeology; and three technological companies. In this paper, the point of view of one such site, that of Passo di Corvo, shall be taken to illustrate project aims.
The objective is to develop at the three sites a system which is able to adapt the suggestion of a visit path to the wishes and needs of various dynamic user profiles. Explanations on what is visible is dependent on the location of the user, which the system is able to detect in real time, as well as on user profile and history of the visit. The user may also connect to other information sources for a better understanding of the archaeological evidence, for example to a local museum where the finds have been stored, or to other sites in the PAST network to find information about related subjects (e. g. how did they cook? how did they bury the dead?).
The project shall exploit available technologies like voice interaction in order to provide tourist assistance at varying level of details.
The methodology defined for PAST will make this experience reproducible to other archaeological sites which may connect to the network when the system will be operational (prototypes at end of 2001).

1. INTRODUCTION

The acronym PAST stands for "exPeriencing Archaeology across Space and Time"; in fact the PAST project aims at improving the understanding of the general public, during a visit to an archaeological site, by helping to solve some typical problems of "space and time" which visitors may experience, such as those presented in the following:

1. In many sites, the area hosted in subsequent periods different populations, with different habits, lifestyles, etc. Unfortunately excavation is destructive, and exposing a lower layer destroys the upper ones. As a consequence, what can be seen is often the result of a selection among different layers (and the appearance of the site to the public can be different to the appearance at any time) or of decisions made by archaeologists to expose one specific layer (and in this case no clue is given about the presence of other civilisations in previous or subsequent historical periods). In all such cases, how habits and culture have evolved and changed along the time in a given place, and possibly until the present times, is very difficult to understand by visitors just looking at ruins in the site.
2. In the same historical period different populations were living in different regions: when visiting a site visitors are forced to take a narrow, local perspective, without any chance of crossing spatial barriers to fully understand commonality and differences in the development of contemporary civilisations in various areas.
3. Findings excavated from a site are typically stored in archaeological museums, and what visitors of a site can therefore see is, in many cases, a set of ruins (foundations, floors, walls, etc.), whose meaning and relevance may be difficult to understand without properly relating them to what was inside (pottery, working tools, etc.).

To facilitate visitors understanding, at present a map with short explanatory text is given to visitors at site entrance, and posters are shown close to important remains. Despite the heterogeneous population of visitors, explanations are necessarily synthetic and standardised, not taking into account the cultural background, the educational level and the specific interests of individual visitors. The only alternative is to buy the services of specialised tourist guides; but this may be very expensive and only a very small percentage of visitors can afford that.

People visiting an archaeological site are thus exposed to extremely fragmented and largely insufficient information, with an approach which is typically standardised, passive, one-way, authoritarian and static vs. both time and space. In this context, archaeological sites are today even more than in the past in danger of loosing "customers", versus other technology-intensive and information-richer means to access historical information, such as CD-ROMs and Internet. Exploitation of advanced ICT in archaeological sites (which are open-air, often distributed over large areas) is very poor, and definitely lagging behind museums. The consequence of that may be dramatic, especially for smaller and less spectacular archaeological sites, which, despite their large number - at least 80% of the about 5.000 sites currently open to public in Europe - currently attract less than 20% of the 120 million yearly visitors of archaeological sites, and whose survival is often in danger.

In the above context, the key strategic objectives of PAST are:

- To revitalise archaeological sites, especially smaller ones, by making visits significantly more attractive and enjoyable, leveraging upon an approach which is information-intensive, active, interactive, personalised, reactive and dynamic.
- To dramatically enhance the ability of visitors to understand the cultural heritage a site represents, by taking an enlarged perspective, beyond the boundaries of space and time.
- To capitalise on previous investments and efforts made in digital preservation of cultural heritage and on existing multimedia archaeological databases, by providing techniques and tools to enable distributed, remote access and effective fruition of their content by visitors of archaeological sites.

To this aim, the PAST project intends to design, develop and validate in 3 pilot installations an advanced infrastructure (the PAST system) relying on innovative technologies like handheld PCs, wireless networks, voice-based human-computer interaction, dynamic user profiling. The project is based on a strict cooperation among technological and archaeological partners, and a further result shall be a methodological framework for implementing the system at other sites. Pilot installations are being developed at three sites, Bibracte in France, Passo di Corvo in Italy and Toumba in Greece.

PAST has just started October 1, 2000, and the rest of the paper shall illustrate project outcome, taking as an example a visit to Passo di Corvo, and the technological framework.

2. VISITING PASSO DI CORVO TODAY

The Foggia territory attracts each year about 3 million tourists, of which about 20% are foreigners, but only 12.000 of them visit the Passo di Corvo Archaeological site and 15.000 the City Museum. Among them, about 3.000 are pupils from local school; therefore, less than 0,5% of tourists visit today the site and the museum.

The Passo di Corvo Neolithic settlement (Tinè 1983) lies 13 km from Foggia. It was identified in the aerial photograph by J.B. Bradford, an English RAF officer, and has been excavated since 1960s. The archaeological site was inaugurated as an Archaeological Park in 1998. The remains, which can be seen in the aerial photograph, have enabled the area of the site to be estimated as covering 130 hectares. This site is the oldest European village where agriculture and cattle allowed a reasonably large number of people to live together, and it is also the largest known European settlement dating back to this period. The village was built in the Neolithic age, and was inhabited between 7000 and 5600 BC The area was rather wet at the time, which caused the excavation of several circular ditches for drainage of fields and huts. Remains of these ditches are still visible, as well as stone floors of huts. It is reported to have hundreds of huts each protected by a "C-shaped" ditch and within each area delimited by these ditches there are wells to supply water and cave-like silos for the preservation of foods. The excavation which is now visible occupies an area of 3,000 square meters, corresponding to less than 1/100 of all of the settlement, but it is sufficient to show how a Neolithic family lived, buried deaths, saved crops and seeds in caves, and how first artisans made flintstone knives and clay pots.

The Passo di Corvo Archaeological Park allows also to see the life-size reconstruction of a hut with its animal pit and inhabitants. The scene reconstructs the life of a family from more than 6,000 years ago, allowing direct confrontation with the archaeological remains present here. The excavation areas can be viewed from above by climbing up a flight of stairs where information boards and an educational laboratory have been purpose-built.

Engraved items, red-striped and white-striped pieces, as well as smooth brown-colored works principally represent the ceramics discovered in the area of the settlement. They are conserved in the Foggia Civic Museum; of particular interest among these are two pieces of obsidian and volcanic rock imported from Lipari or the Island of Melos, giving evidence of trading even over long distances. The museum houses not only the pieces from the excavation, but also educational material (presently miniatures and information boards) related to the Passo di Corvo settlement.

The Passo di Corvo Site is contextualised in the museum in its diachronic relation with the findings on display from other Neolithic settlements of the region. In particular, there are pieces (engraved ceramic vases) from the Neolithic settlement of Guadone, by San Severo, ascribed to the middle of the 6th millennium BC. From another Neolithic settlement near La Quercia Farm comes a different type of ceramic, painted with a red grid motif and on exhibition in the pre-historical section of the museum. Later findings from those reported at the Passo di Corvo settlement are represented in the pieces discovered in the Scaloria Cave in Manfredonia, dating back to about the middle of the 4th millennium BC with connections to a Worship of the Waters.

Apart from items from the Neolithic Age, the Foggia Town Museum preserves items from the Copper Age, the Bronze Age, the Daunia era (IX-IV centuries BC) and the Roman times, from the principal sites of the province of Foggia.

Snapshots taken at the site and at the Civic Museum are shown in the attached CD-ROM.

3. A PAST VISIT TO PASSO DI CORVO

The key idea behind PAST is to use virtual information to enhance the quality of a real visit. This requires, as it will be shown in the next example, the possibility of relating the present user location in the site to the virtual environment. The second key idea is that of personalizing the tour, using user-supplied information: dynamic location recognition, and dynamic update of personal information are then mandatory.
Let us now explain how these concepts are exploited by PAST by describing a visit to Passo di Corvo. A person willing to visit the archaeological site will be able to access its Web site prior to the visit, to book it and to provide a few personal information about himself, his interests, the time available for the visit, etc. The PAST system, based upon such few data, will be able to profile him and to organise a plan for the visit. If the visitor is unable to connect to the web in advance, the same can be done upon arrival at the site through a dedicated PAST Check-in Point, or even during the visit, by interacting with PAST via handheld PC. The visit plan will be real-time generated in a personalised way, taking into account specific interests, time available, existing background, etc., therefore being different for different visitors. (LINDEN *et al.* 1997, PARANAGAMA *et al.* 1997, SHAPIRA *et al.* 1997)
At the entrance of the site, a handheld PC will be given to the visitor to support him during the visit. This device will be able to download the visit plan generated by the PAST system, and it will start guiding the visitor across the site, for instance by driving him in a specific direction, or by pointing him out specific points in the site (e.g., a well, a pavement, etc.). This will be done both graphically, by displaying a map of the site and the current moving location of the visitor, and using text-to-speech technology, by "telling" the visitor where to go next.
When the visitor reaches the first key point in the visit, e.g. the ditch around the village, PAST understands where the visitor is, i.e. it is location-aware. (RYAN *et al.* 1998) It then invites the visitor to stop there, and it starts telling some story about what he is looking at, very much as a professional guide typically does in group visits. The story may be accompanied by drawings, animations, photographs, etc. displayed on the handheld PC's screen. The amount of information and the level of details are not fixed, but they will be different for different visitors: PAST will, in fact, generate different stories and present them differently, based upon its knowledge of the visitor's profile.
PAST will also be able to generate conceptual links between what the visitor is currently looking at in the site, and material stored in digitised form in the Foggia Civic Museum. For instance, tools used in the house-life, found in the site, may be shown when the visitor approaches the place they were found in, and PAST will prompt the visitor with the possibility of accessing an animation re-constructing how the tools were likely be used. The visitor can then decide if he wants to have a look or not, by giving voice commands or via the touch screen.
Also, the PAST system knows that the PAST network includes other archaeological sites, located in different regions, but dating back to the same period; PAST can prompt the visitor with the option of having access to such data and of getting relevant explanations. This will be done by showing options which are meaningful and relevant for a visitor with the given profile, who is at a certain point of its visit, which has available a certain amount of time, etc. The visitor can, therefore, confirm that he wants to know more about, e.g., how people were cooking in Greece, or in France, and PAST will retrieve relevant information and material from the remote archives, by exploiting the Internet as underlying communication infrastructure.
But the visitor may have additional interests, e.g. to understand similarities between burying rituals in the same region, but in different ages: he will express his interests in natural language, via voice commands, and PAST will analyse the query in order to understand what the visitor is interested at. Again, by knowing what is available from other sites and/or museums connected to the PAST network of archaeological sites, PAST will filter available data, and will prompt the visitor with relevant options, among which to choose the one(s) most interesting for him/her. In this way, similarities, differences, time-related and space-related relationships in general, can be highlighted, explained and better understood by visitors, thus offering the opportunity for a deeper understanding not only of the local, but also of the global European Cultural Heritage.
After each user request, PAST besides providing the requested information will also update the visitor's profile. If, for instance, the visitor appears interested in pottery, at the next "stop" of the visit, PAST will automatically provide more details on pottery to the visitor.
Once satisfied with the information and explanation received, the visitor will move to the next "stop" in the visit, which PAST will suggest him, according to the pre-calculated visit path, to be point "X". But if the visitor sees something attractive at point "Y", and decides to move toward "Y" rather than "X". PAST will be able to detect that, and to dynamically re-plan the visit path.
At the end of the visit, PAST will have created a log of the visit made, by recording all the interactions that the visitor has had with PAST to access both information from the physically visited site, and information from the virtually visited sites and museums, connected to the PAST network. If the visitor wishes to do so, at the end of the visit he can purchase either a CD-ROM, or a dedicated, downloadable Web presentation, including his own, personal visit to the site: the CD-ROM may include digital snapshots taken by the visitor with a digital camera, connected to the handheld PC.

4. PAST TECHNOLOGICAL ISSUES: THE WIRELESS NETWORK

Figure 1 shows the underlying architecture of the PAST system: it consists of three main modules, as follows:

- The Server Module, installed at the main office of an archaeological site, which includes the following key components:
  - The PAST Archaeological Repository, storing data relevant to PAST in a Database and providing integration with other existing multimedia archaeological databases (by means of the Legacy Systems Integration Layer).
  - The Visitor Profiler, gathering information about visitors and profiling them.
  - The Visit Organiser, dynamically planning personalised visits and generating personalised information; it also records the visits.
- The Mobile Module, installed on handheld PCs and used by visitors to interact with PAST; its user interface will:

- support interaction via touch-screen, or
- support interaction via voice-commands and natural language, or
- provide text-to-speech functionality.

- The Communication Infrastructure shall support:
  - wireless communication between handheld PCs and the local Server Module installed at the site.
  - web-based communication between PAST systems installed at other archaeological sites or museums, and transparent access, from one site, to data and information residing on the Server Module at another remote site.

In the rest of this Section, we shall concentrate on the most innovative parts of the PAST system, providing more details on handheld PCs and on the types of wireless network, and discussing how the network can be exploited to achieve awareness of visitors location. Further details on the underlying technologies, especially on data representation issues can be found in (ANCONA *et al.* 2000).

The handheld PCs we plan to use are low-costs palmtop devices running Windows CE: HP, Compaq, Casio, Sharp, Canon, Philips make several products in this family available on the market. Such devices are light (about 200 g.), small and wearable (about 12 × 8 × 1.5 cm.), without keyboard, with 256-colour display (320 × 240 pixels, in many cases active-type, therefore with high outdoor readability), with up to 32 Mb memory, with expansion slots for a digital camera or radio connection; last but not least, they are cheap (less than 700 Euro).

Wireless network connection of the handheld PCs to the fixed server will be deployed using compatible cards plugged in the handheld devices: various technologies exist for implementing a wireless network today, and each application must select the one which best matches the intended requirements for price, throughput, reliability and so on. The use of telephone communication technologies, like digital (TDMA/CDMA or GSM) or cellular telephone networks, or digital packed data (CDPD), seems not convenient, mainly for operation costs and low bandwidth. A radio connection is then preferable: the radio frequency spectrum is divided into licensed and unlicensed bands; the latter are regulated, but there is no restriction for access to such bands by individual vendors and they are well open to wide solutions. Thus, PAST exploits DSSS (Direct Sequence Spread Spectrum), which takes a base-band digital signal and replaces, in the transmission of a binary stream, ones and zeroes with codes of fixed length. This produces a bandwidth spread of a large factor. The receiver must use the same code of the transmitter and, through correlation, can recover the transmitted signal when it is merged with noise. Many vendors like Symbol, Aeronet, Netwave support 10 Mbps communication at 2.4 GHZ, and the best option is still under consideration. They all conform to the IEEE Wireless LAN standard 802.11.

The wireless network is then a LAN with the following targets:

- high robustness/reliability: no interference among closely operating units and errors less than $0.5 \cdot 10^{-7}$;
- openness and compatibility with the main network software drivers;
- high performance (2-11 Mbps);
- low cost;
- high scalability (for later expansion to larger number of connected handheld PCs).

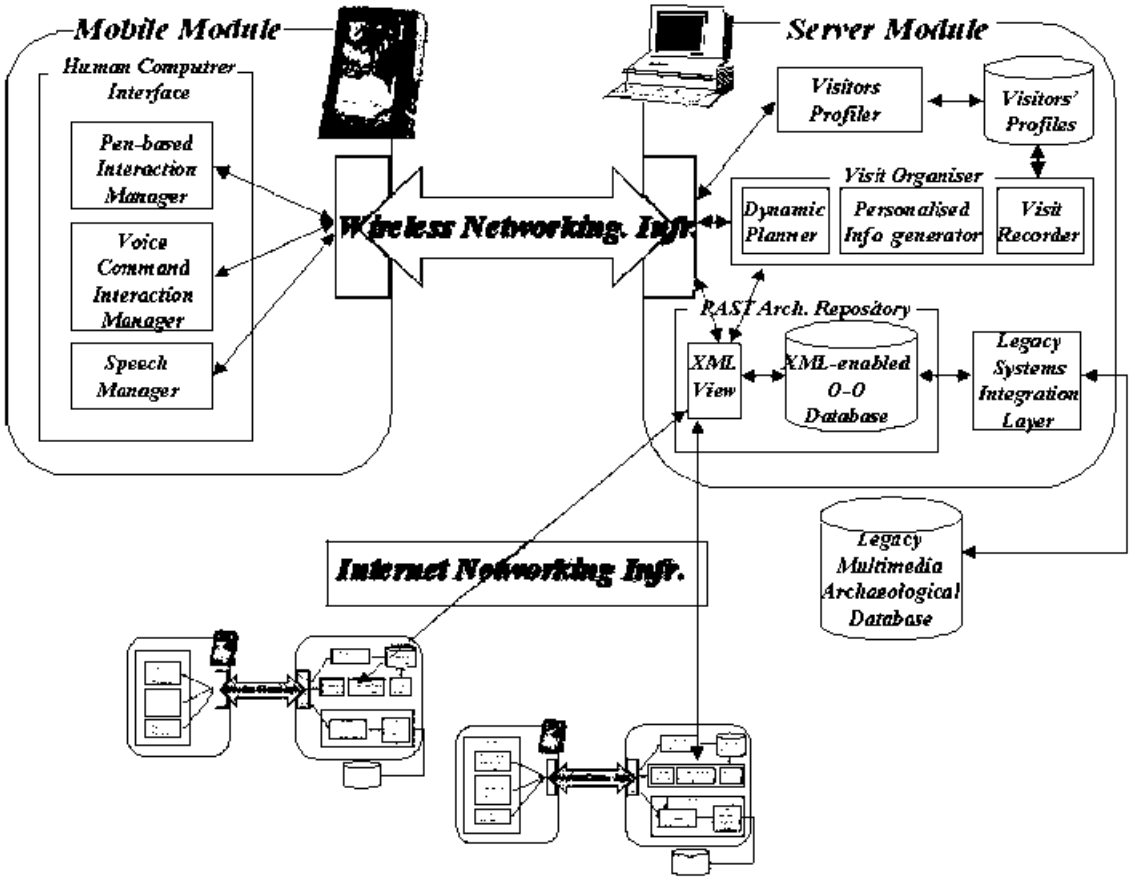

Figure 1. *The PAST system.*

- high precision for location purposes: less than 3 meters error in calculating the position; less than 10 degrees error in calculating the orientation.

An important issue is the speed versus distance: most radio networks operating at 10Mbps cover a range of up to 3 Km in open-air, and require repeaters for larger areas. An initial study carried out at the site of Passo di Corvo has shown that the entire site can be covered by 3 access points and 6 repeaters, giving also a margin of replication and fault tolerance.

We have already remarked that PAST shall locate a visitor in the archaeological site at any point during a visit. This may be achieved by special hardware: current approaches to locate mobile devices in the open air mostly leverage upon the GPS technology. The use of GPS and digital compass in our environment poses several problems: costs, power consumption, size and weight (they need to be attached externally to the handheld PCs), precision (which is low in cheap GPS/compass devices - 30-40 meters; 30-40 degrees of orientation). Moving within an archaeological site requires higher precision in calculating position and orientation, than typically needed when locating visitors in a larger area, such as an entire town. In other projects of tourist assistants like GUIDE (José and Davies 1999), which aimed to directing visitors in the historical points of the city of Lancaster, not all of the city was covered, and the "key locations" were typically more dispersed than in an archaeological site: the precision of PAST was not needed for their purposes. To achieve the needed precision, GPS technology becomes expensive; PAST exploits, on the other hand, an alternative approach, that is using the wireless network to locate mobile devices through triangulation-based software techniques, achieving precision at zero additional hardware costs.

The topology of the wireless network infrastructure will be designed at each site in such a way that each point will be covered by at least 3 repeaters. This will make it possible to analyse, for each repeater, the intensity of the electromagnetic field and of signals received from the handheld PC, and to real-time calculate the exact position of the visitor in the site and his orientation. These data will be exploited to decide which options, menus, information, suggestions, directions, etc. to provide to visitors at any point in a location-sensitive way.

5. CONCLUSIONS

We have briefly outlined the goals of the PAST project from the point of view of one of the pilot sites, namely Passo di Corvo. Of great importance for Foggia is the need to create links between archaeological finds and territorial discoveries, in such a way that the object is not uprooted from its natural environment and acquires a variety of connotations that the dominating culture up until now had taken away, considering it principally to be something untouchable and to admire aesthetically. It is therefore necessary to form a data bank of all the cultural heritage related to the archaeological items and land of the territory of the Foggia Community, and to enable the most effective fruition of such data bank for scientific, public, cultural and tourist use.The PAST project offers an invaluable opportunity to pursue this goal.

Technological issues, which will be the strong points of PAST, include wireless networking and location awareness, both of which have been briefly illustrated.

Handheld PCs to support visitors of open-air monuments have been also recently tried, e.g. by: the GUIDE system (by UK Univ. of Lancaster), the Touring Machine (by Columbia Univ.), the Metronaut (by Carnegie Mellon Univ.). All are able to deliver to visitors location-specific information (e.g. about buildings, monuments, etc.) stored on the hand-held devices themselves, being able to locate visitors via GPS and to guide them through the town. No serious attempts to exploit IT in archaeological sites open to the public is known to the authors so far; but a similar networking structure has already been experienced in the Poliochni 1998 excavations and is described in a companion paper in this book and in (ANCONA *et al.* 1999). See also the web site: http://www.disi.unige.it/person/DoderoG/ramses/main.html (15/12/2000).

In the above scenario, PAST will be innovative in many ways. For example PAST will not only connect handheld PCs to a local Server via wireless networks, but by connecting servers via Internet it will allow visitors to access and exploit a global, distributed information repository, whose richness is order of magnitude larger than possible with state-of-the-art solutions and with current researches.

Moreover, all mentioned systems are rigid and authoritarian in their approach: they prompt visitors with standard information about a given location or about a specific item selected in a fixed list, and the ability of visitors to interact with the systems is very limited. PAST innovation will be in its ability to provide personalised information, to self-adapt its behaviour based on feedback from the visitors and to support a rich two-way interactions with the user.

The PAST project has aggregated a number of IT companies and archaeological sites in 4 European countries, and it is going to deliver its first working prototypes in October 2001 at the three pilot sites, ready for being tested with visitors. The final system shall be due the following year in order to include updates emerging from such first tests.

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