$\mathcal{KORE}$: a Multi-Agent System to Assist Museum Visitors

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***Abstract*— This paper describes a research project aiming at realizing a *personal electronic guide* for a museum visitor. The basic idea is to provide the visitor with the information regarding the work of art she/he is currently looking at. To this aim, we designed a multi-agent architecture, called $\mathcal{KORE}$, which, given that the visitor is equipped with a handheld device (i.e. a Java-enabled PDA or cellular phone), is able to recognize her/his *position*, in the museum, and the picture, sculpture, etc. she/he is looking at; on this basis, $\mathcal{KORE}$ can provide her/him with the information needed to better understand the peculiarities of the work of art, the characteristics of the author, the historical period, etc. Information is suitably filtered and adapted by $\mathcal{KORE}$ on the basis of the "user profile" of the visitor.**

I. Introduction

Currently, every (big) museum has a "personal electronic guide" system which is based on a device, similar to a telephone, with a keyboard and an earphone: when the visitor wants information on a specific work of art, she/he types the "artwork number" on that device and then listens to the information requested, given by means of a pre-registered audio message. This kind of system, even if it solves the basic problem of delivering to the user the information requested, does not present an adequate flexibility needed to take into account the peculiar differences of people visiting the museum: pre-registered audio messages can be surely prepared with different *languages*, but issues such as *age*, *cultural level*, *preferences in arts*, *preferred historical period*, etc., which could affect the information provided, cannot be taken into account. These "parameters", which constitutes the *user profile*, if known to a personal electronic guide system capable of handling them, allow to "tune" the information provided, throwing away those useless for the user (or too difficult or too easy to understand) and delivering only data which match the user profile. This obviously results in providing a better *quality of service*, increasing visitors' satisfaction.

In order to face these issues, a suitable hardware/software architecture is needed, and the design of it is the goal of the $\mathcal{KORE}$ project, which is described in this paper. $\mathcal{KORE}$ is a joint research project of University of Catania and BC Software company aiming at realizing a *personal electronic guide* for a museum visitor. $\mathcal{KORE}$ is based on a multi-agent architecture which, given that the visitor is equipped with a portable device (i.e. a Java-enabled PDA or cellular phone), is able to recognize not only her/his *position* in the museum, but also the picture, sculpture, etc. she/he is looking at; on this basis, $\mathcal{KORE}$ provides the visitor with the information related to that work of art suitable adapted to her/his *user profile*. In designing such an architecture, two basic problems have to be faced, which constitute the characteristics of the $\mathcal{KORE}$ system: (*i*) obtaining the *punctual position* of the user, and in particular the work of art she/he is looking at, and (*ii*) to *adapt* the information on the basis of the user profile of the visitor. The latter problem is twofold: on the one hand, the system has to adapt the information according to the type and characteristics of user's device (this may include not only display capabilities but also the technology used to delivery the data, e.g. infra-red, Wi-Fi, BlueTooth, SMS, etc.); on the other hand, information has to be filtered on the basis of individual user's characteristics, capabilities and attitudes (language, age, level of instruction, preferences, etc.).

The objectives above are met in $\mathcal{KORE}$ by combining infra-red technology with wireless (radio) networks and using a distributed multi-agent architecture able to gather and filter information, according to user profile and characteristics of user's device.

The paper is structured as follows. Section II analyzes similar projects. Section III presents the basic architecture of $\mathcal{KORE}$. Section IV deals with the design issues related to user profiling, user localization and information providing, presenting the solutions adopted in $\mathcal{KORE}$. Section V illustrates the experiences with the prototype implementation. Finally, Section VI reports our conclusions.

II. Related Work

There is a very large number of research projects coping with the problem of seamlessly providing touristic information [2], [5], [1] (most of them are also IST projects) but their focus is different than that of $\mathcal{KORE}$. They concentrate on the problem of assisting a tourist during her/his visit to a town, thus providing information on e.g. interesting monuments, events, etc., and helping in planning touristic itineraries. In these projects, user position is used e.g. to send information on the monument or the part of city currently visited; location is thus obtained by means of well-known technologies, such as BlueTooth (i.e. knowing the cell of the user's device) or GPS/DGPS. These technologies fit well the aim of those

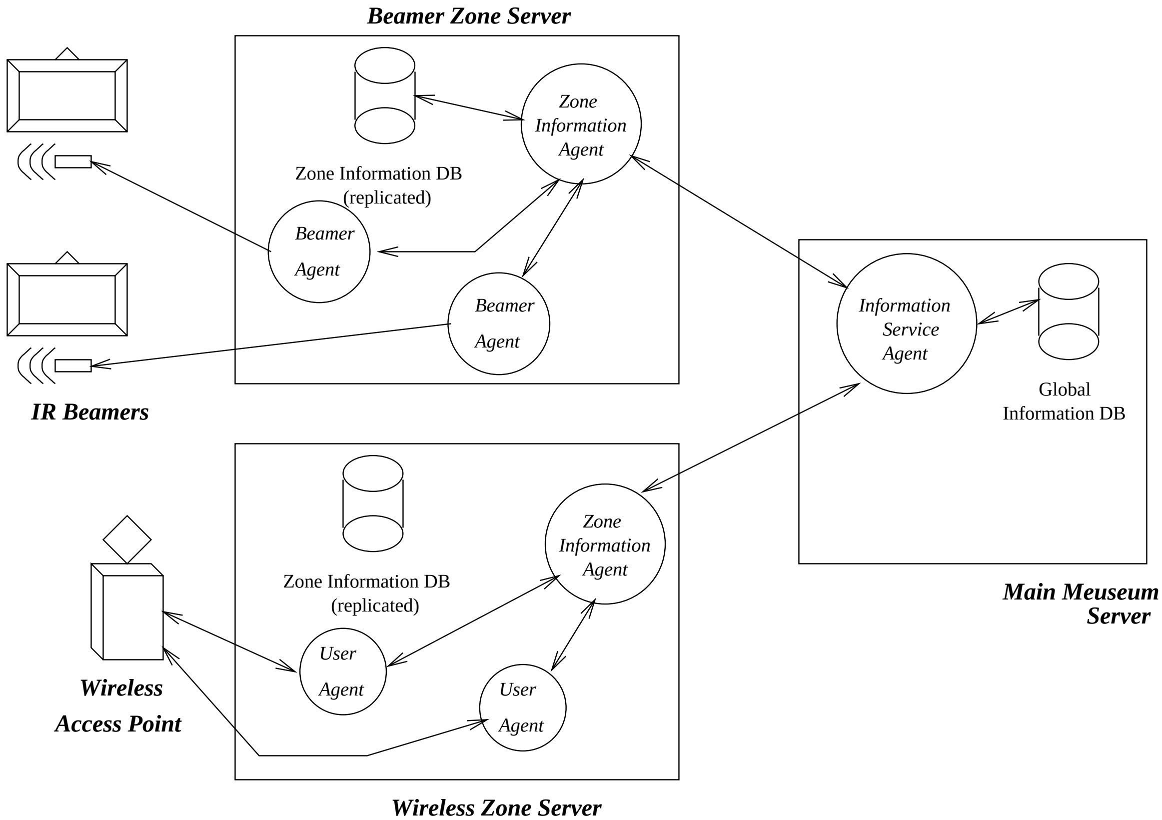

Fig. 1. Architecture of $\mathcal{KORE}$

projects, but cannot be employed in $\mathcal{KORE}$ mainly for two reasons:

- The minimum distance detected by those technologies (at most 1 meter for DGPS) is suited for recognizing e.g. the monument the visitor is looking at, but a work of art (e.g. a picture) could be smaller than 1 meter. In addition, for example, if there are three pictures in a (linear) space of 2 meters, it become difficult to check if the user is looking at the picture in the middle.
- No portable device is currently equipped with a GPS/DGPS system and it is available as an add-on hardware. This is in contrast with the goals of $\mathcal{KORE}$ that aims at allowing the usage of the majority of portable devices "as they were sold", without requiring to install additional features.

Another research project focusing on assisting museum visitors is Cicero [6], [7]. It uses IR beamers placed each one at the entrance of each museum room, thus user localization is performed by detecting in which room she/he is present. On this basis, the client software running on the handheld device, which has a pre-recorded map of the museum, can show the map of the room providing the user with information regarding the artworks in that room. In this case, it's up the user to select, through the client GUI, which work of art she/he is looking at. Although valid, if compared to $\mathcal{KORE}$, the approach of Cicero requires a knowledge embedded in the portable device and is not able to detect the punctual position of the user, as $\mathcal{KORE}$ does.

III. The Architecture

In this Section we will sketch the architecture of $\mathcal{KORE}$, illustrating its basic functionalities. Detailed information on the various parts of the system will be instead given in subsequent Section IV.

The architecture of $\mathcal{KORE}$, which is depicted in Figure 1, is based on a distributed system made of some servers, installed in the various zones of the museums, which host some specialized agents.

A centralized **Main Museum Server** embeds a database containing the information regarding all of the artworks present in the museum (work description, author's biography, etc.), while some **Zone Servers**, each serving a specific zone of the museum host a database containing the information (replicated from the Main Server) of the artworks related to that zone. Zone Servers are responsible for providing users present in the associated zone of the museum with the information related to the artworks (of that zone).

User localization is performed by using infra-red beamers placed near each artwork, while information is provided by means of a wireless (radio) connection, or by the same infra-red beamers, if the user's device is not capable of wireless communication.

User profile identification, user chasing and information filtering on the basis of user profile are performed by a set of cooperating agents hosted in the various servers of the system. The **Information Service Agent** provides services to access the main museum database. The **Zone Information Agent**s (one for each zone server) are responsible of managing the zone information database, providing access to it; these agents cooperate with the Information Service Agent to ensure consistency of replicated data. The **Beamer Agent**s have instead the task of driving IR beamers—micro-controllered devices interconnected through a bus—which continuously send information as detailed in Sect. IV-C. Finally, **User Agent**s (one for each museum visitor) are responsible for providing information to each associated user (if the latter has a device capable of a wireless connection). While other agents are essentially used as service providers, User Agents are *intelligent* and *mobile*: intelligence is needed to monitor user actions (i.e. artworks looked at) trying to update, on this basis, visitor preferences and thus her/his user profile; mobility is exploited to chase the user moving from zone to zone.

IV. Design Issues of $\mathcal{KORE}$

The main issues, which we had to dealt with in designing $\mathcal{KORE}$, are how to *profile the user* and suitably utilize profiling information, how to *detect user position* and how to *provide information* on the basis of user position and profile. The solution adopted are detailed in the following Subsections.

A. Profiling the User

As $\mathcal{KORE}$ provides to the user with information on the basis of her/his characteristics, the *user profile* has to be known to the system. To this aim, $\mathcal{KORE}$ manages the following profile information:

- *Personal preferences*, such as language, age, level of instruction, preferred art type, preferred historical period, etc.
- *Device capabilities*, such as screen size, number of colors, etc.

All these information are managed by the client application running on the portable device of the user, the $\mathcal{KORE}$ Browser. *Device capabilities* are automatically detected by the $\mathcal{KORE}$ Browser while *personal preferences* are gathered by means of the activation of the "Preferences" menu of the $\mathcal{KORE}$ Browser. Profile data is thus stored on the user's portable device and then used to appropriately filter and adapt information provided; this is performed differently on the basis of the communication medium used to access the handheld device, as detailed in Sect. IV-C.

Preference data is used by the $\mathcal{KORE}$ Browser to determine what are the *categories* to which the user belongs; this is made by matching preferences with a set of predetermined categories, fixed at design time and coded into the $\mathcal{KORE}$ Browser. Even if this approach could seem not flexible (categories are coded in $\mathcal{KORE}$ Browser), it is a quite enough to provide, in a short time, a prototype implementation, which is needed to perform some tests in order to prove the validity of the choices made and the feasibility of the designed system. Indeed, since categories depend on information to provide, each museum could organize them differently. For this reason, future work will aim at adding flexibility to user categorization by trying to dynamically detect the categories of each user, when she/he enters in a museum, by performing matching of the user profile with the categories chosen and defined by that museum.

B. Detecting User Position

The problem of user location in $\mathcal{KORE}$ features two main characteristics: *directionality* and *fine resolution*. We decided to adopt infra-red (IR) technology since, in our opinion, it is the most suited for the following reason:

- *It is wide-spread.* Every portable device has a built-in IR connection and no additional hardware is needed. The same does not applies e.g. for GPS or BlueTooth.
- *It is highly directional.* By suitably tuning emission angle and power of IR emitters, a precise and small zone can be delimited.

$\mathcal{KORE}$ system thus perform user localization by means of IR beamers placed near the artworks of the museum. A different IR beamer is place near each artwork and it send continuously a serial packet containing a unique *work of art identifier (WAI)* (the packet contains also other information which will be detailed in Sect. IV-C). When the user approaches the work of art, she/he has simply to appropriately point her/his portable device in order to allow the latter to receive the *WAI* beamed. On this basis, the client software installed on the device, the $\mathcal{KORE}$ Browser, is able to detect the work of art the user is currently looking at and retrieve the needed information as detailed in the next Subsection.

C. Providing/Retrieving Information

Since a goal of $\mathcal{KORE}$ is to support many kind of portable devices, we categorize the devices which can be used with $\mathcal{KORE}$ as:

1) *Devices capable of IR connection only* (e.g. Palm IIIx/Vx/m505/m515, etc.).
2) *Devices equipped with IR and a wireless connection* such as GSM, BlueTooth or Wi-Fi (e.g. Compaq iPAQ, Motorola T720, Nokia 3650, Palm Tungsten, etc.).

As far as the former category is concerned, information are provided using IR beamers. In fact, the packet sent by each beamer includes not only the *WAI* but also the information of the work of art related to that beamer. Since more than one user at the same time can look at the same a work of art, a single beamer has to serve more than user device at time; information is thus broadcasted using a one-way beamer-to-device continuously transmission. Since IR communication may be affected by transmission errors, each packet is checksummed (by using a CRC-16 polynomial): if a reception error occurs, the $\mathcal{KORE}$ Browser waits for the arrival of the next retransmission of the same packet, trying to correct the errors (this is a technique widely used in Teletext and Teletext-based data broadcasting [8]). For this reason, packets must be small and information related to the work of art must

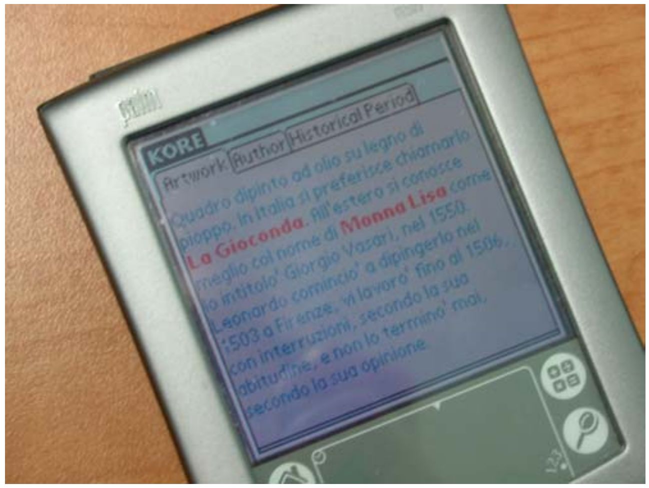

Fig. 2. The $\mathcal{KORE}$ Browser running on a Palm m505

thus be fragmented in several packets; this means that, only when all fragments have been received, the information can be displayed by the $\mathcal{KORE}$ Browser. To this aim, packets embed a *packet number*—to re-assemble fragments—and a *last packet flag*—to detect last information fragment.

Information adaptation on the basis of user profile is made by means of an additional packet field which specifies the *categories* to which the associated information is destined. It is a bit-mapped field where each bit is associated to a certain category: if the bit is set, then information carried in the packet is for that category of users. On this basis, the $\mathcal{KORE}$ Browser is able to filter received data, presenting to the user only the information relevant to categories to which user belongs.

As for devices equipped with a wireless connection, information is provided "on demand". The $\mathcal{KORE}$ Browser, once received the *WAI* (via infra-red) sends, through the wireless channel, a request to the Zone Information Agent of the Zone Server of the zone. The Zone Information Agent checks if the requesting user has yet associated a *User Agent*[1] and it routes the request to the latter. Otherwise, it spawns a new User Agent which contacts visitor's handheld, in order to obtain the user profile. When the User Agent receives the request, it gathers and provides the information desired suitably filtered on the basis of user profile. When a visitor changes museum zone, the User Agent (which is mobile) migrates to the new Zone Server. This is required in order to not interrupt User Agent background activities that, as introduced in Sect. III, aim at updating user profile on the basis of the artworks chosen during the tour.

V. Implementation Issues

While the basic architecture of $\mathcal{KORE}$ is yet designed, we are working on defining the details of each module in order to provide a first prototype implementation of the whole system. We chose JADE [4] as the agent platform and already made some experiments using a Palm m505 PDA equipped with the Superwaba Java virtual machine [3] (see Figure 2). Experiments made allowed us to test the localization technique and information providing through infra-red transmission channel (we used some portable PCs to emulate IR beamers), thus demonstrating the validity of the proposed localization approach.

[1] If this is the first request issued by the visitor after she/he entered the museum, no User Agent is associated to her/him.

VI. Conclusions

We presented, in this paper, a multi-agent system aiming at providing a "personal guide" to a museum visitor equipped with a handheld device. The architecture has been designed so as to allow the use of the majority of portable devices and, to this aim, it employs different technologies to seamlessly provide information to a moving user. Location awareness is obtained by means of infra-red technology; the same is used to send artwork data to devices not capable of a wireless connection. Tests made proved the validity of our approach. Experiments were done by using a first prototype implementation of some parts of the system, that is still at a development stage.

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