User Profile Agents for Cultural Heritage fruition

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Abstract. In this paper we present an application of a MAS (Multi-Agent System) composed of logical agents in an Ambient Intelligence scenario, related to the fruition of cultural assets. The users are located in an area which is known to the agents: in the application, the users are the visitors of Villa Adriana, an archaeological site in Tivoli, near Rome (Italy). Agents are aware of user moves by means of Galileo satellite signal, i.e., the proposed application is based on a blend of different technologies. The agents, developed in the DALI logic programming language, proactively learn and/or enhance users profiles and are thus capable to competently assist the users during their visit, to elicit habits and preferences and to propose cultural assets to the users according to the learned profile.

1 INTRODUCTION

The paradigm of Ambient Intelligence implies the objective of building a friendly environment where all of us will be surrounded by "intelligent" electronic devices, and this ambient should be sensitive and responsive to our needs. A multitude of sensors and actuators are already embedded in very-small or very large information and communication technologies, and a challenging task nowadays is to identify which advantages can be gained from these technology systems. Tourism for instance is a context where old and new aspects can be melted for reaching interesting results. In fact, tourism is a growing industry and it needs to evolve according to the tourists changing features. In the past, tourists were satisfied with standardized package tours. Today, with the popularization of traveling, tourists are expecting new tour experiences that are different and authentic [13].

Most cultural tour sites today still maintain a conventional form of tour that is static and provides a visitor with plenty of information, which is however lacking any form of customization. Several interesting works have proposed a new manner of enjoying cultural places, as technology may support more dynamic and personalized methods to conceive the fruition of cultural assets. Park et al. in [11] propose a system named "Immersive tour post". It uses audio and video technology to provide improved tour experiences at cultural tour sites and. This system take the form of a post that stays fixed in one location and reproduces the vision and sounds of the historical event that occurred at the particular space. Mobile applications in a mobile-environment have been experimented by Pilato et al. in [12].

Visitors are assisted in their route within the "Parco Archeologico della Valle dei Templi" (archaeological area with ancient Greek temples) in Agrigento (Sicily, Italy) by an user-friendly virtual-guide system called MAGA, adaptable to the users needs of mobility. MAGA exploits speech recognition technologies and location detection, thus allowing a natural interaction with the user. Each visitor can access the information on cultural assets via a portable device (PDA, or "Personal Digital Assistant") that, through RFIDs (which are well-known standard an automatic identification method), is able to capture where the person is in the Parco.

Several other proposals can be found in the literature, exploring the integration between human-computer interaction and information presentation. The system Minerva, proposed by Amigoni et al. in [1] organizes virtual museums, starting from the collections of objects and the environments in which they must be displayed while the DramaTour methodology presented by Damiano et al. in [8] explores a visit scenario in an historical location of Turin. Visitors are assisted by a virtual spider that monitors their behavior and reactively proposes the history of the palace in detail and a lot of funny anecdotes about the people. Studying the human behavior during the visit in a cultural heritage scenario is an exciting aim.

The systems presented above have a common characteristic: they try to improve the traditional methods to inform the visitor by means of new catchy techniques for making the human-machine interface more friendly and intuitive. But, is it possible to go beyond, towards capturing the visitors desires and expectations? A particular mechanism for capturing the visitor interest for one or more cultural assets has been presented by Bhusate at al. in [2]. Each visitor receives a PDA associated to non-invasive sensors that measure "affective" context data such as the user's skin conductance and temperature. The sensor readings are reported to a control module that determines, according to other data, the visitor's mood. Preferences can be also catched by asking questions directly to the user before starting the visit.

This method has been adopted in the system KORE [3] where parameters such as age, cultural level, preferences in arts, preferred historical period, etc., are taken into account for "tuning" the pieces of information provided, by throwing away those useless for the user (either too difficult or too easy to understand) and delivering only data which match the user profile. The architecture of KORE is based on a distributed system composed of some servers, installed in the various areas of museums, which host specialized agents. The KORE system practically demonstrates that intelligent agents can have a relevant role in capturing the user profile by observing the visitor behavior. They possess the capability to be autonomous and to remain active while the visitor completes her/his visit; they can percept through the sensors all choices performed by the user and, consequently, activate a reasoning process.

In this paper, we present the architecture of the MAS DALICA applied to the Villa Adriana scenario for capturing the visitors interests and enhancing their profiles. Similarly to what happens in the KORE

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system, each DALICA intelligent agent starts its activity with the cashing of data such as the visitors' age, preferences, cultural level and so on. Then, it captures additional data about the visitor's movements and choices, elaborates them and updates the user profile. The visitor's movements are traced by means of the Galileo satellite. The learned profile allows DALICA to offer information on the cultural assets adapted to the visitor, and to proactively propose to see those assets closer on the one hand to the visitor's physical position and one the other hand to the the visitor's preferences. The related items of information are provided in an appropriate customized form. As acknowledged in Section 7, the DALICA system has been developed within the CUSPIS European project.

In Section 2 we present the scenario where DALICA has been put at work and the features of the system. We also discuss the methods through which the intelligent agents are capable to capture the visitors' interest and the monitoring capabilities of the agents. Sections 3 and 4 are dedicated to the DALI language in which DALICA has been implemented and to show how its features have been exploited for defining the agents. In Section 5 the practical application of the resulting MAS is illustrated. Finally, we conclude in Section 6.

2 THE DALICA SYSTEM

The case-study on which the development of DALICA has been based is that of constructing and updating the user profile of visitors of Villa Adriana in Tivoli near Rome (Italy). Villa Adriana is an exceptional complex of classical buildings created in the 2nd century A.D. by the Roman emperor Hadrian. It combines the best elements of the architectural heritage of Egypt, Greece and Rome in the form of an 'ideal city' [14].

For a visitor, Villa Adriana is a unique wonderful place. For DALICA, Villa Adriana as a set of Points of Interest (POI's). For "POI" we intend either a specific cultural asset like the "Pecile" (shown in the picture below) or public places like restaurants located nearby. The first part of our work has been concerned with the study of the scenario of Villa Adriana for individuating the characteristics of the POIs useful for the agent reasoning process. For this purpose we have defined a POI as a set of the following fields:

- *Identifier*: a string identifying uniquely the POI;
- *Latitude*: the latitude of the POI defined through the Galileo satellite.
- *Longitude*: the longitude of the POI defined through the Galileo satellite.
- *Radius*: the radius of the circle that contains the POI area.
- *Keywords*: a list of the POI characteristics like, for example, 'mosaic' if the POI contains a mosaic, or 'water' if in the POI there is a fountain or a water basin. Considering that each POI can have one or more keywords, we combined each one with a number indicating its weight (relative importance) in the POI description. For example, assuming that the "Pecile" usually captures the attention of a visitor prevalently for the water basin while the mosaic maintains a very marginal role, the list of the keywords will be $[(water, 60), (garden, 30), (mosaic, 10)]$. Clearly, this information has been provided by experts.
- *Time for visit*: is an average of the time that we suppose an user will employ for visiting the specific POI.

The POIs descriptions have been collected into an appropriate ontology (developed by the group of Artificial Intelligence and Natural Language Processing at the Dept. for Computer Science, Systems and Management of the University of Rome Tor Vergata, in the context of the CUSPIS project).

For example, for defining the "Pecile", we use the following string: $poi('VA\_PecileV1', 41.94201257700091, 12.77403535070269, 80, [('mosaic', 10), ('water', 40), ('statue', 20), ('garden', 10), ('column', 20)], 10)$.

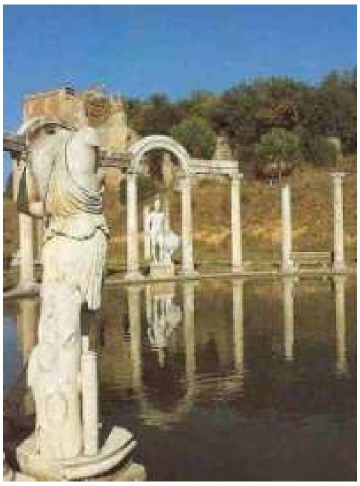

Figure 1. Pecile in Villa Adriana

The picture of the "Pecile confirms the correspondence between some keywords and the effective features of the POI. Keywords are important because they allow to establish the possible similarities between POIs and, consequently, to discover if the visitor is interested in some particular feature which is common to them. E.g., if in Villa Adriana a visitor decides to visit the "Pecile", the "Teatro Marittimo", the "Canopo", the "Piccole" and the "Grandi Terme", it is plausible to assume that she/he could be interested in those POIs where the water has a relevant role.

In this scenario, we have developed and experimented DALICA MAS. The main goal of the system has been that of supporting users during their visits. This implies capturing their profiles and offering them a customized information on the cultural assets, including proposals for extending the visit, for new visits of for other visits to related places, better if located nearby. Each visitor, at the beginning of the visit, has to book the route in an Internet site where she/he can express some preferences and choices about the service fruition. Then, each visitor is provided with a PDA by which the movements and the choices of the visitor can be observed, so that she/he can receive suitable information on the cultural assets.

When the visitor starts her/his route, an intelligent agent, called User Profile One, is generated. At the staring phase, it elaborates the data coming from the user-profile stored in Internet and determines an initial fruition profile. Then, it re-elaborates the fruition profile according to the new data derived from the user behavior. New enhanced fruition profiles will possibly substitute the former one while the visitor proceeds in the route.

At this point, it is necessary to explain through which strategies is possible to capture the visitors interests in a scenario such as Villa Adriana, where the cultural assets are arranged in an area of 300 hectares.

2.1 Deducing the Visitor's Interests

Intelligent agents in DALICA are reactive, pro-active and communicative. Their are capable to percept the data coming from the environment such as the satellite coordinates or the POIs chosen by the visitor and to react appropriately. While reactivity allows the agents to adopt a specific behavior in response to the external perception, pro-activity has a main role, because the reasoning process that leads to the interests deduction is based on the correlation of several data coming from the environment, from the ontology and from some basic inferential processes.

Communication capabilities intervene whenever it is necessary to send data to the visitor's PDA: e.g., the explanations of what is being seen or the list of the deduced interests or the proposed other POIs to see or the warning that the visitor is entering in a restricted area. In the rest of this section we concentrate the attention on the methods used for deducing the user interests, while in next section we present the strategies for assisting her/him during the visit and for checking her/his behavior.

We divide the agent deduction process into three phases: the first one represents a basic deduction level while the second and third ones elaborate the results by concatenating the previous deductions. We starts the explanation by illustrating the algorithms concerning the first phase:

Deducing the interests based on time: This algorithm is founded on the consideration that a visitor is interested in a POI if she/he observes it for a time interval "longer" than the average time of the visit for the specific cultural asset. The meaning of "longer" can be modulated according to the current visitor's profile. So, if a visitor has booked a visit that lasts up to six hours the time interval for the observation will be longer than that of a visitor that booked a visit lasting for two hours.

How is it possible to determine which POI the visitor is looking at? The method is based on the Galileo Satellite. Each POI, as explained in the previous section, is identified by a circle (whose center is defined by a latitude and a longitude) and by a radius. If the visitor position (expressed in latitude and longitude and coming from the PDA) belongs to the circle related to a specific POI, we can suppose that she/he is visiting that POI. If two or more POIs are close enough to determine an intersection between their circles and the visitor is located in the intersection, then the algorithm, not being able to capture the real intention of the visitor, presumes that the visitor is interested in all those POIs. Each POI which is selected according to the visitor movements is identified by a list of keywords. The algorithm elaborates the keywords of all selected POIs and then extrapolates the most frequent ones. These keywords represent the hypothetical user interests that, once deduced, will have to be confirmed both by subsequent user behavior and by other deduction mechanisms.

Deducing the interests based on the visited POIs: This algorithm considers the POIs chosen by the user and its outcome improves when several POIs have already been visited. In fact, for each POI the algorithm extracts the keywords and the most frequent ones are asserted as "deduced interest".

Deducing the interests based on the chosen route: If a visitor decides to follow a predefined route chosen between those proposed by the system, the agent tries to capture the visitor's interests by studying the POIs included in the route. Each POI will have a list of keywords and those most relevant for describing the route will be selected for the next step of the deduction process.

Deducing the interests by similarity: This algorithm employs a similarity measure. In particular, the interests expressed by the visitor in the web site are matched with those in the ontology. Those in the ontology which look to be similar enough are selected as deduced interests.

Deducing the interests according to some questions: Another strategy for capturing the visitor's interests is centered on some occasional questions about the POIs located near the visitor. The agent observes the POIs around the PDA, chooses one of them and asks the visitor's opinion on it. A positive response such as ("Yes, I like the Odeon") will trigger the interests deduction process.

Deducing the interests according to cultural questions: The last strategy for deducing the visitor's interests takes into consideration the cultural level of the visitor. Some questions such as "Do you like the ancient art? Do you know what is a cavea?" are useful to determine the information level to submit to the visitor. Moreover, some parameters such as the visitor's job and age are involved in the process. The agent compares the data acquired via the questions and via the other parameters and elaborates them in order to determine the appropriate degree of the information. We have identified for now three degrees.

- **Basic**: It is related to a basic information level where the user prefers a superficial information on the POIs combined with details on the ancient people's life. This level usually fits primary and secondary students and occasional visitors.
- **Medium**: Provides more technical data on POIs and particular attention is reserved to their structure. This level fits people fond of art.
- **Specialized**: Provides the visitor with a detailed information on POIs combined with information about the materials and techniques used to manage the cultural assets. This level is tailored to specialized students, technical people, researchers and so on.

The second deduction phase captures the results of the previous deduction algorithms and tries to compare them, with the aim of reaching a more precise user profile definition. In particular, those interests coming from the previous phase and confirmed by this second one are involved in a process that selects only the most frequent ones. These interests are sent to the visitor's PDA in order to be confirmed by her/him. Precisely, this second phase is based on the following algorithms:

Filtering the deduced interests according to the time: This filter combines the deduction of the interests based on the permanence near a certain POI and the moment when the deduction itself has been reached. In particular, this step has the objective of understanding whether a visitor remained in a specific area because interested in a POI or for some other reason (e.g., she/he was sitting on a lawn eating a sandwich). The reasoning process is presently pretty simple, and will be improved in the future. We suppose that a visitor could be interested in eating especially at a certain time (say from 12:30 to 14:30). If the visitor has not spent some time in a restaurant area and the deduction has been reached after 12:30 and before the 14:30, then the hypothesis of eating a sandwich has to be taken into account with a higher priority than at other moments of the day.

Each deduced interest is involved in a *interests updating process*. More precisely, we each interest/keyword is associated to a weight (priority) N. For a specific deduced interest K, we have define a global evaluation function computed on the weights. In this manner, the system takes in account not only the interests more frequently deduced but also their 'relevance' in the deduction process.

Combining the deduced interests: The interests deduced by the previous algorithms based on time, on visited POIs, on the chosen route and according to some questions are crossed in order to obtain a more reliable user profile definition. The interests which are confirmed will be involved in the *interests updating process*.

Using similarity for confirming the deduced interests: Reliability of the interests deduced in the previous phase is checked according to the similarity degree with those inserted in the visitor's profile in the web site. If the similarity is greater than a prefixed threshold, the interest will be involved in the *interests updating process*.

The third phase delivers data related to the elicited interests to the visitor's PDA. When the visitor receives the interests list, she/he can confirm either all interests or a subset of them. The selected interests are managed by the agent for updating the user profile. Moreover, the agent communicates them to a central system that manages the information for the visitor in order to propose (through the agent) data and POIs closer to his desires and expectations.

2.2 Monitoring Visitor's Behavior

Intelligent agents in DALICA are also used for monitoring the users behavior. The situations where the reactive and proactive capabilities of the agents are put at work are at least the following.

Checking the forbidden areas: In Villa Adriana there are areas where visitors cannot enter. These areas are defined in the ontology and an agent monitors from time to time the visitors' movements in order to guarantee that no one transgress the rules. If a visitor enters in a forbidden area, the agent sends to his PDA an alert and informs the authorities about the violation. **Monitoring the visitors route**: The agent has the ability to follow the visitor that has chosen a predefined route along his visit. The activity of the agent is centered on two possibilities. (i) *The visitor is fast*: when the visitor that has decided to visit Villa Adriana by following a predefined route, finishes it quickly and has time for visiting others POIs, the agent, according to the user profile and to their distance, proposes one or more additional POIs. (ii) *The visitor is slow*: if the visitor has to finish his visit within a certain time and the agent reaches the conclusion that he could not visit all POIs in the route without quickening one's pace, it sends to the visitor's PDA a warning.

Creating a list of POIs: When the visitor has finished the visit, the agent collects all POIs that he has visited and puts them in a file with texts and images. This allows the visitor to keep a reminder of his visit to Villa Adriana.

2.3 The DALICA Architecture

The DALICA architecture involves a MAS and a central external system. This system on the one hand acts as a "router" between the MAS and the PDA's: in fact, the MAS is presently too heavy to be directly installed on the PDA's. Thus, the MAS resides on a more powerful machine and uses the central system to exchange data with the PDA's. It receives messages from from/to the agents and delivers them from/to to the PDAs of the visitors. On the other hand, the central system collects and stores data about visitors and visits for future use.

In the DALICA MAS, several intelligent agents cooperate in order to support the users during their visit. The three most important agents composing the MAS are the following.

Generator Agent: The role of this agent is to automatically generate the User Profile agents when a usert starts a visit. The generation process happens when PDA sends a positioning message related to a new visitor. This reactive capability is combined with a set of pro-active functions that check from time to time if the User Profile agents are active and, if not, generate them again.

User Profile Agent: Acts as described before in this section. They deduce the visitors interests and monitor their behaviors.

Output Agent: Manages communications between the DALICA MAS and an external central system.

The following picture illustrated the DALICA architecture:

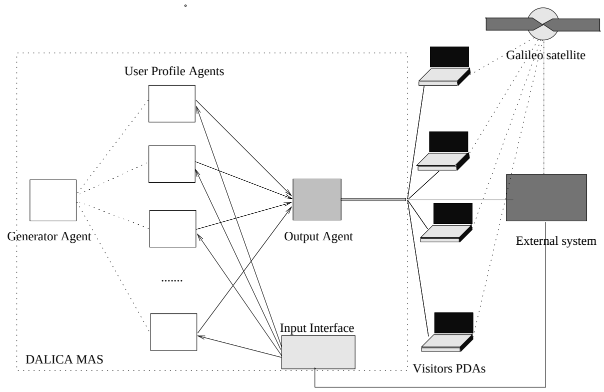

Figure 2. DALICA MAS

The MAS receives data about the user movements and actions coming from the visitors PDAs via the Input Interface. This interface is not an agent. It has the role to deliver messages to and from the external system into the Linda Tuple Space through which the intelligent agents in the DALICA MAS communicate.

DALICA agents have been implemented in the DALI language, which is shortly described in the following section.

3 THE DALI LANGUAGE IN A NUTSHELL

DALI [4] [5] [15] [6] [7] is an Active Logic Programming language designed in the line of [9] for executable specification of logical agents. DALI is a prolog-like logic programming language with a prolog-like declarative and procedural semantics [10]. In order to introduce reactive and proactive capabilities, the basic logic language has been syntactically, semantically and procedurally enhanced by introducing several kinds of *events*, managed by suitable *reactive rules*. All the events and actions are timestamped, so as to record when they occurred. These features are summarized very shortly below.

An *external event* is a particular stimulus perceived by the agent from the environment. We define the set of external events perceived by the agent from time t_1 to time t_n as a set $E = \{e_1 : t_1, ..., e_n : t_n\}$ where $E \subseteq S$. and the e_i's are atoms. indicated with postfix E in order to be distinguished from both plain atoms and other DALI events.

External events allow an agent to react through a particular kind of rules, reactive rules, aimed at interacting with the external environment. When an event comes into the agent from its external world, the agent can perceive it and decide to react. The reaction is defined by a reactive rule which has in its head that external event. The special token :>, used instead of $: -$, indicates that reactive rules performs forward reasoning.

A reactive rule has the form: $ExtEvent_E \;\; :> \;\; Body$ or $ExtEvent_{1E}, ..., ExtEvent_{nE} \;\; :> \;\; Body$ where $Body$ has the usual (logic programming) syntax and intended meaning except that it may contain the DALI event and action atoms which are introduced below..

The *internal event* concept allow DALI agents to be proactive independently of the environment by reacting to its own conclusion (which can be considered as a form of introspection). More precisely: An internal event is syntactically indicated by postfix I and implies the definition of two rules. The first one contains the conditions (knowledge, past events, procedures, etc.) that must be true so that the reaction (in the second rule) may happen:

$IntEvent : -Conditions$
$IntEvent_I :> Body$

Internal events are automatically attempted with a default frequency customizable by means of user directives in the initialization file that can tune also other parameters such as how many times an agent must react to the internal event (forever, once, twice,...) and when (forever, when triggering conditions occur, ...); how long the event must be attempted (until some time, until some terminating conditions, forever).

Actions are the agent's way of affecting the environment, possibly in reaction to either an external or internal event. An action in DALI can be also a message sent by an agent to another one. An action atom is syntactically indicated by postfix A. Clearly, when an atom corresponding to an action occurs in the inference process, the action is supposed to be actually performed by suitable "actuators" that connect the agent with its environment. In DALI, actions may have or not preconditions: in the former case, the actions are defined by actions rules, in the latter case they are just action atoms. An action rule is just a plain rule, but in order to emphasize that it is related to an action, we have introduced the new token $:<$.

External and internal events that have happened (i.e., that have been reacted to) and actions that have been performed are recorded as past events, that represent the agent's memory, and the basis of its "experience".

4 REACTIVITY AND PROACTIVITY IN DALICA

In this section, we present a snapshot of the User Profile Agent, paying a particular attention to some reactive and proactive capabilities of the agent implemented in DALI. The signal of the Galileo satellite is received by the agent by means of a DALI reactive rule:

```
posE(Lat,Lng,Time,Date,Integrity,_):>
def_position(Lat,Lng,Time,Date,Integrity).

def_position(_,_,_,_,Integrity):-
           Integrity=0,
           no_correct_signalA.
def_position(Lat,Lng,Time,Date,Integrity):-
           Integrity=1,
           positionA(Lat,Lng,Time,Date,1).
def_position(Lat,Lng,Time,Date,Integrity):-
           Integrity=2,
           positionA(Lat,Lng,Time,Date,2).
```

where Lat and Lng are, respectively, the latitude and the longitude of the visitor's position and Time and Date have the obvious meaning. This reactive rule "filters" the Galileo signal according to its integrity value. Only if the integrity is different from 0, the signal is accepted and, by means of the action $positionA(Lat, Lng, Time, Date, \_)$, is used by the proactive rules for the inferential activities. In fact, the action $positionA(Lat, Lng, Time, Date, \_)$ is transformed into the past event $positionA(Lat, Lng, Time, Date, \_)$.

As an example of the pro-active capabilities of the agent, we show the check about entering forbidden areas. This check employs two internal events, represented by two couples of DALI rules. As mentioned above, the conclusion of the first of each couple of rules is automatically attempted from time to time. If it is true (i.e., it has been proved), possibly returning some values for input variables, then the body of the second rule (the reactive one) is executed, after assigning the values to the variables.

```
check_forbidden_area(Lat,Lng):-
   positionP(Lat,Lng,_,_,_).
check_forbidden_areaI(Lat,Lng):>
   findall(X,clause(forbidden_area(X,_),_),L),
   examine_forb_area(Lat,Lng,L).

examine_forb_area(_,_,[]).
examine_forb_area(Lat,Lng,[A|_]):-
   clause(forbidden_area(A,Li),_),
   belong_forbidden area(Lat,Lng,Li),
   genera_code(I),
   clause(agent(S),_),
   clause(message_forbidden_area(Mfa),_),
   clause(user_terminal(UT),_),
   messageA(transfer,
   send_message(xinfotransfer_
   message(I,S,UT,Mfa),S)),
   clause(system_address(SA),_),
   messageA(transfer,
   send_message(xinfotransfer_
   message(I,S,SA,Mfa),S)).
examine_forb_area(Lat,Lng,[A|B]):-
   clause(forbidden_area(A,Li),_),
   not(belong_forbidden_area(Lat,Lng,Li)),
   examine_forb_area(Lat,Lng,B).
```

Then, $check\_forbidden\_area(Lat, Lng)$ is an internal event that is triggered each time the agent receives a new correct position. The procedure $belong\_forbidden\_area(Lat, Lng, Li)$ verifies if the position belongs to a forbidden area. A positive response forces the agent to send a message to the user PDA and to the central system for alerting the authorities.

5 AGENTS AT WORK

In this section we propose a snapshot of the User Profile Agent behavior in the scenario of Villa Adriana. We consider a set of visitor's positions and the result of the deduction process according to the given ontology. We suppose that the user is walking in an area near the *Quadriportico* and at a certain moment she/he starts walking around the POI. The *Quadriporticois* described in the ontology as follows:

$poi('VA\_quadriportico', 41.940977, 12.775163, 25,$
$[('mosaic', 33), ('garden', 34), ('fresco', 33)], 8).$

I.e., the center of the circle describing the area of the *Quadriportico* is defined by the couple 41.940977,12.775163 of Galileo coordinates. Moreover, the radius of the circle is assumed to be 25 meters and the *Quadriportico* can be described by the interests *mosaic*, *garden* and *fresco*. None of them is overcoming the others, so they have similar weights. A relevant parameter for deducing that the visitor could be interested in this POI is the time for visit assumed to be around 8 minutes. We suppose for this example that the user movements are concentrated in the area described by the following coordinates:

(41.940605,12.774419);(41.94073,12.774741);
(41.940916,12.775011); (41.940897,12.775358);
(41.941058,12.775358);(41.941069,12.775108);
(41.940958,12.775013);(41.940863,12.775136);
(41.940955,12.775325); (41.941077,12.775255);
(41.941008,12.775025);(41.941008,12.775025).

Some positions are repeated because a visitor could stay still. After having sent these positions to the User Profile Agent by means of the visitor's PDA, the result is synthesized by the shell of the agent:

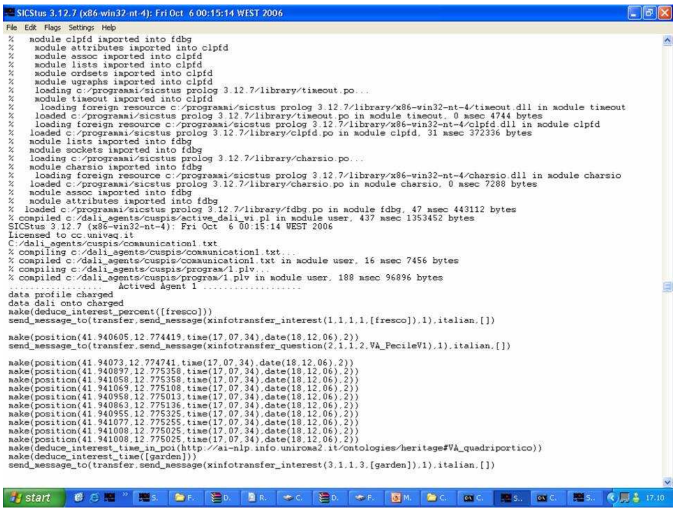

Figure 3. DALICA MAS at work

In this case, we suppose that we are in the afternoon, after 14:30. The figure shows what the agent has deduced: the visitor is presumably interested in *garden*, one of the interests belonging to the POI *Quadriportico*. Then, the agent sends the interest *garden* to the *transfer* that is the name of the *Output Agent*. The latter will dispatch the message to the visitor's PDA.

6 CONCLUSIONS

We conclude this paper by making some considerations about our work. It is not so easy to find an application where intelligent agents are put at work in a real scenario but it is even less frequent to find intelligent logical agents at work. In the light of these considerations, the DALICA MAS is a novelty. This also because DALICA exploits the signal of Galileo Satellites to deduce the Users Profiles. DALICA at work in the area of Villa Adriana practically demonstrated that logical agents can be applied successfully for capturing the visitors habits and preferences.

Our system cannot be compared with platforms such as MAGA and DramaTour where the main goal is to offer information to the visitors via specialized interfaces. DALICA mainly deduces the visitors interests and leaves the job of presenting the information to an external component. KORE is the system closer to DALICA because it uses agents for managing the information through the study of the User Profile. KORE does not use the Galileo signal and its agents are not logical. Moreover, DALICA is more centered on the deduction profile process while KORE mainly filters the information according to the User Profile characteristics.

As future developments, the system reasoning capabilities that are presently quite basic can be improved. Also, previous experience can be better exploited. Different agents managing different visitors might communicate so as to cooperate in improving their performance and enhancing the services they offer.

7 ACKNOWLEDGEMENTS

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