DALICA Agents applied to a Cultural Heritage scenario

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Abstract

In this paper we discuss the potential contributions that agent technology can bring into an Ambient Intelligence scenario, related to the fruition and monitoring of cultural assets. The users are located in an area which is known to the agents: in the application, for the cultural assets scenario the users are the visitors of Villa Adriana, an archaeological site in Tivoli, near Rome (Italy) while for the monitoring scenario works of arts have been transported from a museum in Rome to another one in Florence. 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

Villa Adriana is a fascinating and enormous archaeological area, where old and modern artifacts have found a particular and unexpected equilibrium. Old as the huge monuments whose history is carved in the stones, modern as the infrastructures which has been built for supporting visitors during their visit. Modern as the PDAs[1] and as the Galileo satellite signal: these advanced technologies have been merged together with the equally advanced software technology of Intelligent Logical Agents. In this paper, we discuss and describe how intelligent logical agents have been exploited in the context of the CUSPIS European project to build an Ambient Intelligence scenario, related to the fruition and monitoring of cultural assets. The resulting system has been put at work in Villa Adriana and its surroundings, coping with two significant aspects: the cultural assets fruition (for short CAF) and the cultural assets monitoring (for short CAM).

[1]Personal Digital Assistants, which are hand-held devices that combine computing, telephone/fax, Internet and networking features.

The fruition scenario concerns the dissemination of information about cultural assets: e.g., people can go round in either a museum or an archaeological site and receive on their mobile devices appropriate and personalized items of information related to the cultural assets they are visiting. In the approach proposed here, each user is assisted by an agent that acts as a guide during the visit, suggests routes and proposes suitable pieces of information. This by starting from a standard user profile which the agent later on tries to improve by eliciting the user's cultural level, habits and preferences. The enhanced profile will lead the agent to update the route and to propose customized information, including suggestions for future possible visits either to the same or to other locations. The Galileo Open Service (OS) [13, 10] allows the agents to follow users during their visit and, as we will discuss later, may be of help for capturing their habits and preferences.

The monitoring scenario concerns the secure transport of cultural assets from the owner (the organization that holds them) to the renter (the organization requiring them) and vice versa. In the CAM scenario, agents are used for monitoring the cultural assets transport so as to enhance security. Agents analyze the data (e.g., temperature, humidity, light and geographical positions) detected by suitable sensors located into the cultural assets packs and reactively and cooperatively infer possible thefts. Also, agents monitor the routing and other sensible factors.

The multi-agent system that we have designed and implemented for CAF and CAM is called DALICA. It has been implemented in DALI, a logical agent-oriented language that some of the authors of this paper have previously specified and developed.

The paper is organized as follows. In Section 2 we discuss our choice to implement DALICA by means of DALI logical agents. In Section 3 we discuss how the complex environment in which DALICA is put at work can be modeled. In Section 4 we introduce some relevant concepts relative to the ontology adopted by the agents. Section 5 illustrates the methods DALICA agents adopt to capture the visitors' interests and to monitor their behavior. In Section 6 we briefly illustrate a small part of the implementation, to give at least an idea of its effectiveness, and we illustrate some aspects of the DALI language. In Section 7 the practical application of the resulting MAS is illustrated. Finally, we discuss related work in Section 8 and then conclude in Section 9.

2 Motivation: why DALI logical agents

Agents and multi-agent systems (MAS) have emerged as a powerful technology to face the complexity of a variety of scenarios where some kind of autonomy is needed. There are now several industrial applications that demonstrate the advantage of using agents. However, agent systems have yet to achieve widespread deployment in operating environments, as technology has to move from pure research to development. DALICA is an interesting example in this sense, as it has been fully implemented and put at work in a real-world non-trivial scenario.

Platforms for building autonomous software require dedicated basic concept and languages. At the level of individual agents, representational elements such as observations, actions, beliefs, goal are required. As for the functionalities that every agent-oriented framework has to provide: reactivity is the ability of an agent to perceive its external environment and take appropriate measures in response to perceptions; proactivity is the ability of an agent to take initiatives based on its own evaluation of relevant conditions; social ability includes the ability of an agent of communicating with the other agents with suitable modalities. In fact, a multi-agent system (MAS) is a collection of software agents that work in conjunction with each other. Going further on the line of autonomous software, new applications need "intelligence", in the sense of the ability to exhibit, compose and adapt behaviors, and to be able to learn the appropriate way of (better) performing a task rather than being instructed in advance.

Among the potential applications, distributed monitoring/control systems (DCMS for short) appear to be a natural realm for agents, by virtue of controllers being in principle autonomous entities. The DALICA scenario can be seen as a distributed monitoring system. The "objects" of the agents monitoring activity are on the one hand the user to be assisted during the visit to an area. The degree of control here is loose, as the user can be advised to follow a route or to pay particular attention to a specific piece of art, but of course retains her/his autonomy. The degree of control might increase if, in the future, the system would be extended so as to assist disabled people. On the other hand however, the system has to check that forbidden areas are not violated, that people do not concentrate into limited areas, that they quit the area at the end of opening hours, that they are informed and assisted about interesting events, e.g. a concert, and about unlucky events, like the area having to close up for security reasons or because of the weather being rapidly getting worse.

In the particular DCMS that we are considering, some kind of "intelligence" is needed so as to interact with users in a flexible customizable evolving way, rather than through predefined rigid unalterable patterns. Computational logic can play a relevant role in this sense, as a good tool for building intelligent agents. Also due to their traditional "fast prototyping" character, to the new efficient implementation and to the new concepts they are able to embody, logic languages are good candidates for experimenting such advanced applications. In fact, the DALICA system has been implemented in DALI, a logical agent-oriented language defined and implemented at the University of L' Aquila (see [4], [5], [14]).

3 Modeling the Environment

Due to the complex heterogeneous nature of the environment where the system that we describe is put at work, a preliminary discussion about how such an environment can be modeled is in order.

The distributed nature of the environment of DALICA led us to the definition introduced in [8], where an environment can be modeled as a set of cells assembled into a network. If we consider the perceptions coming into the DALICA MAS, we conclude to be actually allowed to consider the environment as a set of several specialized cells. For instance, a cell is constituted by the ontological description of the site where the agents are put at work (in our case-study Villa Adriana) where monuments and services are mapped. But also the perceptions (positions and preferences) coming from each visitors' device can be considered as belonging to a particular cell.

The global database containing information about the visitors profiles and, in the transport scenario, the perceptions coming from the devices that control the works of art health conditions can in turn be understood as specialized cells. The different levels of abstraction of the information coming from different cells triggers suitable kinds of activity in the DALICA agents.

This concept of multiple layers can be formalized by means of the approach of [15] where the environment is decomposed into building blocks called *environment abstractions*. Each environment abstraction is an entity encapsulating some function o service for the agents. As an example of such a function, consider the satellite signal authentication process adopted in the transport monitoring scenario. According to this perspective, the cells defined above form a number of different environment blocks, or layers. The MAS Middleware Layer allow us to formalize the underlying infrastructures.

We can distinguish among three levels of support that the environment can provide. The first one is the *basic level*, including external resources with which the MAS interacts. These resources for us are the visitors PDAs, the repository of transport digital certificates, the global database and all other hardware components of the overall CUSPIS system which includes the MAS. The second one is the *abstraction level* bridging the gap between the agent abstraction and low-level details of the deployment context. To this level belongs, for example, the MAS ontology, the authentication infrastructure, the communication one and so on. Finally, the third level is the *interaction-mediation* level which encompasses the mechanisms for mediated interaction. The MAS infrastructures for coordinating the Control Device Agents in the transport scenario and for organizing the visitors' activities find their natural collocation in this level. At the top of the environment levels are the working agent applications.

Our approach to modeling the environment is a synthesis of previously described ones: the environment is seen as divided into several different contexts, each one providing not just data but rather (or also) functions and services, at various levels of abstraction.

Figure 1 shows the infrastructure for environment abstractions in the CUSPIS MAS application.

At the bottom level, the physical support specifies the hardware components of the overall CUSPIS system where the DALICA MAS has been integrated into, i.e., the visitors PDAs, the Galileo infrastructure, etc. The PDA receives the Galileo signal and transmits the visitor's position to the CUSPIS system that delivers it to the MAS.

The execution platform specifies the operating systems, the virtual machine and other middlewares. The Application Agents area contains three kinds of agents belonging to the MAS:

Generator Agent: The role of this agent is to automatically generate the User Profile agents when a user initiates a visit.

User Profile Agent: Each visitor is associated to a User Profile Agent that deduces her/his interests and monitors her/his behaviors as discussed later.

Output Agent: Manages communications between the DALICA MAS and external infrastructures.

Finally, the Application Environment contains: the Ontology Interface, that allows agents to get information about the Villa Adriana context; the Visitor data interface,

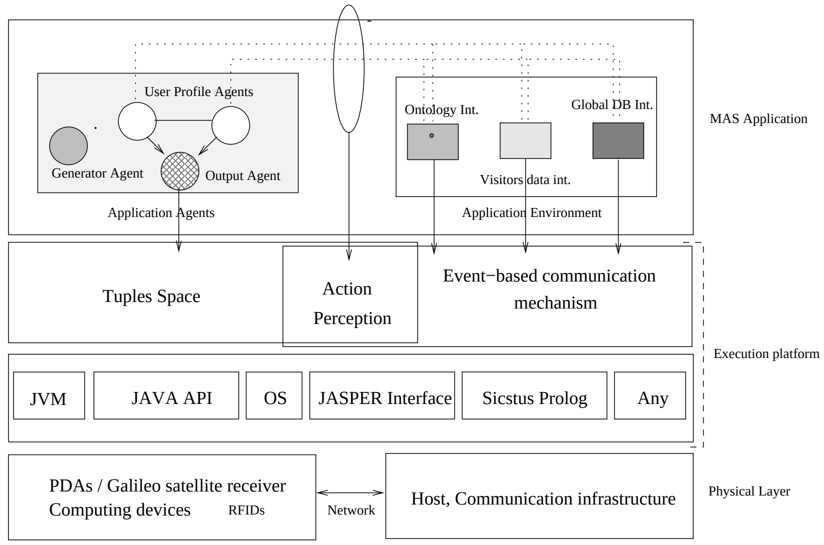

Figure 1: MAS Environment Application Layers for the fruition scenario

that communicates to the MAS the visitors positions and data (responses to questions interests, etc.); the Global DB interface contains the User Profiles and other global information.

4 The DALICA ontology

For making Villa Adriana ’understandable’ for agents, the knowledge about the domain has been represented as a set of Points of Interest (POI’s). For “POI” we intend either a specific cultural asset or some public place (e.g, a restaurant) located nearby.

The structure of a POI includes the following fields:
Identifier: a string that uniquely identifies 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 a 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 either a fountain or a water basin. In case a POI has several keywords, each one has a ’weight’ chosen according to the relative importance (expressed as a percent value). For example, assuming that the “Pecile” usually captures the attention of a visitor prevalently for the water basin while the mosaic has 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 the average time a user is supposed to dedicate to the POI (again according to experts).

The POIs descriptions have been collected into an appropriate ontology (developed by the group of Artificial Intelligence and Natural Language Processing at the Dept. of Computer Science, Systems and Management at the University of Rome Tor Vergata, in the context of the CUSPIS project).
For instance, the following string defines “Pecile”:
$poi('VA\_PecileV1', 41.942012, 12.774035, 80,$
$[('mosaic', 10), ('water', 40), ('statue', 20),$
$('garden', 10), ('column', 20)], 10).$

Keywords allow the possible similarities between POIs to be established and, consequently, allow agents to understand if the visitor is interested in a 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 because the keywords related to it have, in all those POIs, a weight greater than that of the other keywords.

5 Constructing and Enhancing the User Profile

The main goal of the DALICA MAS system is that of supporting users during their visits. For this reason, when an user starts a visit a DALICA agent is created for supervising and assisting her/him. Agents create and update the user profile starting from an embryonal version provided by the user before starting the visit. This initial profile contains some basic data related to the visitor (name, age, job etc.) and some data related to the visit that she/he intends to perform (day of the visit, starting and ending time and, optionally, additional data such as preferences, etc.). Preferences are expressed in terms of the POI characteristics that are of interest to the user (e.g., this user like gardens). The DALICA MAS will take them into consideration for proposing POIs to the user. For example, if the user declares to be interested in 'mosaic' and 'gardens', the system should select for him those POIs in Villa Adriana where the above keywords have an high weight value.

When the visitor starts her/his route, an agent called “User Profile One” is generated. At the staring stage, it elaborates the data coming from the initial profile. Then, it re-elaborates the 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.

5.1 Deducing the Visitor's Interests

Intelligent agents in DALICA MAS are reactive, pro-active and communicative. They are capable to perceive the data coming from the environment such as the satellite coordinates or the POIs chosen by the visitor and to react appropriately. Reactivity allows the agents to adopt a specific behavior in response to the external perceptions. 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.

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 relating previous deductions. We start the explanation by illustrating the algorithms concerning the first phase.

Deducing the interests based on time: This algorithm is based on assuming that a visitor may be interested in a POI if she/he observes it for a time interval "longer" than the average time of visit for that specific cultural asset. The meaning of "longer" can be modulated according to the current visitor's profile.

It is possible to determine which POI the visitor is looking at by means of the Galileo Satellite signal. Namely, each POI 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 within the intersection, then the algorithm (clearly not being able to capture the real intentions of the visitor) *presumes* that the visitor is interested in all those POIs. The algorithm considers the keywords of all selected POIs to extrapolate the most frequent ones. These keywords represent the (present) assumed 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 so that reliability and precision improves as the number of visited POI's increases. 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 that route.

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 the ontology. The ontology elements that are considered to be similar enough are selected as deduced interests.

Deducing the interests according to explicit questions: Another strategy for capturing the visitor's interests is centered on occasional questions about the POIs located near the visitor.

Deducing the interests according to cultural questions: The last strategy for deducing the visitor's interests takes into consideration the (self-declared) cultural level of the visitor. Elements such as the visitor's job and age are involved in the process. The agent compares the data acquired via questions and in other ways and elaborates them in order to determine the appropriate information accuracy degree. We have provisionally identified three degrees.

The second deduction stage tries to compare the results of the previous stages, with the aim of further refining the 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 the most frequent ones. The user may be asked for confirm if it is deemed necessary, though an agent objective is to result as non-intrusive as possible.

The third phase is that of sending to the visitor the elicited interests list, that she/he can confirm partially or totally. 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.

5.2 Monitoring Visitor's Behavior

Intelligent agents in DALICA MAS 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: 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. 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, but finishes it quickly and has time for visiting others POIs then the agent, according to the user profile and to their distance, proposes one or more additional places to visit. (ii) *The visitor is slow*: if the visitor has to complete his visit within a certain time and the agent reaches the conclusion that he could not visit all POIs in the route in the predefined time, 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 she has visited and puts them in a file with texts and images. This allows the visitor to keep a reminder of her visit to Villa Adriana.

5.3 Organizing the users' activities

User Profile agents are entities that live in the Ambient Intelligence scenario in Villa Adriana and assist the users during their visit. So, in Villa Adriana two parallel worlds interact: the humans and the agents. The cooperation activity in the DALICA MAS is based on the assumptions that the visitors can have common interests and can decide to share their time. The existence of common interests among users can be detected by the agents quite easily: they construct and manage the user profiles and can exchange information about them. At a certain point of the visit, when an agent has collected enough information about the user profile, it starts a cooperation activity with the other User Profile Agents.

The main goal of this activity is to discover if within a reasonable geographical area there exist other visitors having a similar profile that are willing to share the rest of the visit with other persons. This negotiation process could be extended to other users activities as the dinner in a particular restaurant or the visit of other museums and so on.

5.4 Monitoring the Cultural Assets transport

It is very difficult and maybe impossible to totally eliminate the risks involved in the transport phase. In fact, the cultural assets transport hides risks, delays, anxieties and difficulties due to the unpredictability of the events.

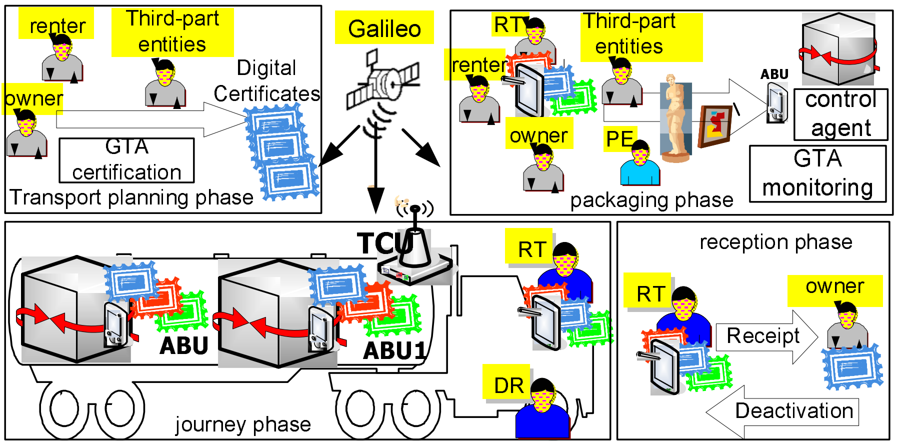

Figure 2: Transport of cultural assets

In previous work, we have combined the Galileo infrastructure with security mechanisms thus obtaining the *Geo Time Authentication system (GTA)* [9]. The GTA provides the following services: (i) cultural asset identification and authentication; (ii) integrity of cultural assets information; (iii) secure transport of cultural assets. Secure transport is achieved by means of the GTA monitoring component. A device equipped with this component is wrapped in each cultural asset package and is connected to several sensors (i.e., temperature, humidity and light sensors). At run time, the GTA monitoring component controls the sensor data variation to detect possible package opening, it checks the mutual position among packages to detect possible thefts and uses the Galileo signal to check the correct transport routing.

However, in our real experiments [7] we have noticed that the GTA monitoring component can rise false alarms. These may be consequence of unexpected environmental conditions (e.g. quickly weather breaks, suddenly track breaking) that require some intelligent deductions missing in the GTA implementation. To this aim, in this section we present our recent enhancements of the GTA system by means of the deduction capabilities of intelligent agents. In this scenario, a DALICA agent is used for checking several transport parameters and for informing the authorities in case there is a suspect of either tampering or theft. In the following, we describe the transport of cultural assets (see Figure 2) emphasizing the agents roles.

In the transport planning phase, the owner of the cultural assets together with the renter (i.e., the entity who wishes to take the cultural assets) and third-part entities (i.e., who vouches for the content and the routing of transport) cooperate to produce different certificates. We focus on the authorization and the transport certificates since they are used by the DALICA intelligent agents. Each package of the transport is equipped with an authorization certificate that contains the list of all cultural assets inserted in the package. This certificate is used to check the actual presence of the cultural assets inside the package itself.

When a transport has been planned, exactly one transport certificate that contains the correct routing is generated. The routing is defined in terms of: (i) the starting transport area and the related date (i.e., day and hour); (ii) the areas where the transport must pass and the related dates; (iii) the destination area and its date. In the experiments that we have performed in the context of the CUSPIS project, the owner of the cultural assets was a museum in Rome, the renter of cultural assets a museum in Florence and third-part entities were the Ministry of Cultural Heritage, the Insurance Company and the Transport.

In the packaging phase, the above-mentioned entities, in cooperation with the responsible of transport (RT) and the packaging expert (PE), supervise the packaging of assets. Each package is filled with: (i) a set of assets each of them identified by an RFID (which is a standard identification device); (ii) a Control Device (called ABU); (iii) a sensor of humidity; (iv) a sensor of light; (v) a sensor of temperature. In particular, the ABU is a powerful mobile device which hosts both a Control Device Agent and a GTA monitoring component. While the GTA monitoring component provides security by traditional mechanisms (i.e., cryptography, certificates and detection algorithm) the Control Device Agent enhances security issues through intelligent deductions. In fact, in the real implementation both the agent and GTA components can implement the same security checking thus providing a further layer of security.

In the journey phase, each control agent employs its proactive capability to perform the following activities: (i) correct routing checking; (ii) cultural assets verification; (iii) sensor data checking; (iv) package position verification.

The Correct routing checking is performed by the Control Device Agent by exploiting both the Galileo signal and the transport certificate. In particular, the agent uses the Galileo satellite to check that each area is passed at the right time. The cultural assets verification is an activity in which the control agent loads all cultural assets IDs contained in the authorization certificate and checks their presence inside the package. It is worth noticing that this activity is performed repeatedly over time. Both correct routing checking and cultural assets verification are also performed by the GTA monitoring component. Therefore, the agents contribution consists in redundant checks that enhance the system fault-tolerance.

The sensor data checking verifies the variation of the sensor data over time. This variation must not exceed a given threshold that, as we are going to see in the following, is dynamically adapted by means of the agents cooperation. This check ensures that a package is not either opened or kept in a dangerous environment.

The package position verification ensures that all packages are in the correct position. In this process, the agents exploit their cooperation capabilities. In fact, from time to time each Control Device Agent sends a message to the other ones asking for their position. Then, it computes the distance and verifies that the (relative) position does not vary over time. In fact, a variation of the package mutual position can imply a package theft but can also due to a quickly break. In this case, the agent reasoning is indeed needed to enhance the whole system effectiveness by detecting and avoiding GTA false alarms. When the DALICA MAS detects some anomaly, it sends a warning message.

We remark that the use of intelligent agents supports traditional security mechanisms to enhance security issues in the cultural assets transport. In fact, the communication capabilities of the agents permits to adapt the predefined thresholds to new environmental conditions. If, e.g., the temperature of the environment changes for all packs due to a natural process and overcomes the threshold, the agents in the ABUs can activate a communication process and reach the conclusion that no package has been tampered because each of them signals the same temperature. In this case, the agents do not send an alert but rather cooperate with the GTA monitoring component to adapt the new temperature threshold.

6 DALICA Implementation

In this section, we briefly illustrate a small part of the implementation, to give at least an idea of its effectiveness and also in order to illustrate some aspects of the DALI language (described in [4], [5] and [14]). However, the DALICA system has been experimented both for CAM, in a transport from Rome to Florence, and for CAF, in the area of Villa Adriana. DALICA has been successfully demonstrated to the stakeholders of the CUSPIS project.

In particular, we present a snapshot of the User Profile Agent, paying particular attention to some reactive and proactive capabilities of the agent implemented in DALI. For the sake of providing an understandable illustration in short space, the code snapshots that we illustrate are necessarily trivial.

The signal of the Galileo satellite is received by the agent by means of a DALI reactive rule, where $posE(\ldots)$ is an *external event*, i.e. the perception of something that has happened in external world: namely, in this case it is the information about the user's current position, where Lat and Lng are, respectively, the latitude and the longitude of the visitor's position, $Time$ and $Date$ have the obvious meaning and $Integrity$ indicates how well the signal has been received. 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.

```
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).
```

This reactive rule "filters" the Galileo signal according to its integrity value (indicating the quality of the signal). Only if the integrity is different from 0 (acceptable quality) then the signal is accepted. The action $positionA$ $(Lat, Lng, Time, Date, \_)$ is then recorded, so that position data are made available to the pro-active rules for subsequent inferential activities. Position data will be updated by subsequent detections of the satellite signal.

As an example of the pro-active capabilities of the agent, we show the check about entering forbidden areas. This check employs an internal event, represented by two couples of DALI rules. The first of each couple of rules is automatically attempted from time to time. If it succeeds, 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.

The rule $check\_forbidden\_area(Lat, Lng)$ 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. The communication primitive $infotransfer\_message(I, S, SA, Mfa)$ contains a code (Mfa) specifying the kind of communication act that the agent is performing (in this case, a "forbidden area" alert).

```
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).
```

7 Agents at work

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


```
make(deduce_interest_time_in_poi(http://ontologies/heritage#VA_GrandiTerme2))
make(deduce_interest_time_in_poi(http://ontologies/heritage#VA_IlPretorioVista))
make(position(41.93948,12.775775,time(13,38,40),date(15,11,06),1))
make(deduce_interest_time([(thermae,0.25)]))
make(position(41.939476,12.775773,time(13,38,45),date(15,11,06),1))
make(position(41.939487,12.775773,time(13,38,50),date(15,11,06),1))
make(position(41.939487,12.775762,time(13,38,55),date(15,11,06),1))
make(position(41.939495,12.775768,time(13,39,00),date(15,11,06),1))
make(position(41.939503,12.775775,time(13,39,05),date(15,11,06),1))
make(position(41.939503,12.775784,time(13,39,10),date(15,11,06),1))
make(position(41.93947,12.775784,time(13,39,15),date(15,11,06),1))
make(position(41.93945,12.775765,time(13,39,20),date(15,11,06),1))
make(position(41.93944,12.775759,time(13,39,25),date(15,11,06),1))
make(position(41.939438,12.775752,time(13,39,30),date(15,11,06),1))
make(position(41.93943,12.7757435,time(13,39,35),date(15,11,06),1))
make(position(41.93942,12.77573,time(13,39,40),date(15,11,06),1))
send_message_to(transfer,send_message(question(8,1,1,8,VA_IlPretorio),1))
```

Figure 3: DALICA MAS at work

$poi('VA\_IlPretorio', 41.939503, 12.775775, 25,$
$[('columns', 0.30), ('opus', 0.30), ('fresco', 0.30), ('arc', 0.10)], 8).$

I.e., the center of the circle describing the area of the *Pretorio* is defined by the couple (41.939503,12.775775) of Galileo coordinates. The radius of the circle is assumed to be 25 meters and the *Pretorio* can be described by the keywords *columns*, *opus*, *fresco* and *arc*. 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:

(41.93948,12.775775);(41.939476,12.775773);
(41.939487,12.775773); (41.939487,12.775772);
(41.939495,12.775768);(41.939503,12.775775);
(41.939503,12.775784);(41.93945,12.7755765);
(41.93944,12.775759); (41.939438,12.775752);
(41.93943,12.7757435);(41.9394,12.77573).

Some positions can be repeated because a visitor could stay still. These positions are communicated to the User Profile Agent by means of the visitor's PDA. We suppose that we are in the afternoon, after 13:30. Figure 3 illustrates the User Profile agent behavior: the entity has already deduced an interest (based on time of visit) in Grandi Terme and Pretorio Vista. That will induce the agent to assume that the visitor is presumably interested in *thermae*, one of the interests belonging to the POI *Grandi Terme*. Then, the agent sends the interest *thermae* to the *transfer* Output Agent, that will dispatch the message to the visitor's PDA. Finally the agent sends questions about

Pretorio and waits for a reply by the user in order to understand his preferences and send personalized information.

8 Related work

Several interesting works have proposed a new way of enjoying cultural places, exploiting technology for the fruition of cultural assets. Park et al. in [11] propose a system named "Immersive tour post", that takes the form of a post that stays fixed in one location and reproduces the vision and sounds of the historical events that occurred in that particular place. 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, which exploits speech recognition technologies and location detection.

The Minerva system, proposed in [1], organizes virtual museums starting from the collections of objects and the environments in which they must be displayed. In the DramaTour methodology presented by Damiano et al. in [6] visitors are assisted by a virtual spider that monitors their behavior and reactively proposes pieces of information about the history with a lot of funny anecdotes.

The above-presented systems have a common feature: 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. Bhusate at al. in [2] go further: 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.

In the KORE system [3], parameters such as age, cultural level, preferences in arts, preferred historical period, etc., are taken into account for "tuning" the pieces of information provided. 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. In our opinion, KORE is the system closer to DALICA, as it uses agents for managing the information through the study of the User Profile. KORE does not however exploit the Galileo signal and its agents are not logical.

9 Conclusions

We conclude this paper by considering that it is not so easy to find an application where intelligent agents are put at work in a real scenario. It is even less frequent to find intelligent logical agents at work in a complex environment. Thus, the DALICA MAS is a novelty. This also because the DALICA MAS exploits the signal of Galileo Satellites in order to deduce the Users Profiles, in an original and useful blend of different technologies. The DALICA MAS at work in the area of Villa Adriana practically demonstrates the potential of logical agents for implementing non-trivial applications.

The add-ons for the users consist in the possibility to get at a low price the advantages of a personalized assistance, while keeping the advantages of a free visit without strict limitations such as those imposed by joining an organized group. Other advantages are those of receiving information about other potentially interesting locations (selected according to the elicited profile). Also, the users can exploit their assistant in many ways, including the possibility of identifying (if they wish) other people with similar interests.

As future developments, the system reasoning capabilities that are presently quite basic can be improved. Also, previous experience of both agents and users can be better exploited. In the near future, we mean to improve the system so as to assist disabled people in cultural assets fruition.

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