AMIMaS: Model of architecture based on Multi-Agent Systems for the development of applications and services on AmI spaces

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Abstract

People life are surrounded with information and communication technology (ICT) forcing us to cope with a great amount of technologies. These technologies each time are more complex the interaction techniques of them. Ambience Intelligent tries to facilitate this task to the user with the help of intelligent agent; even to implant an Ambient Intelligent system is not easy.

In this paper describes a model of architecture based on Multi-Agent Systems defined to develop services and applications in Ambient Intelligence Spaces.

1. Introduction

Ambient Intelligence (AmI) Spaces are physical spaces where services and applications of AmI are offered. AmI is the group of technologies that surrounds people in an invisible and non-intrusive way, without physical or psychological constraints acting, wherever and whenever needed, in proactively, making their life richer.

The key concept of the proposed architecture model is the intelligent agent. An intelligent agent is a computational system that is able to operate in an autonomous and flexible way in a determinate runtime environment. Multi-Agent Systems (MAS) are composed by many intelligent agents that interact with each other.

The agent definition fits within ambient intelligence, since both of them are systems that can take information from an external environment, are able to process it and then, can perform actions on this environment related to this process. For this reason, intelligent agents are used to implement AmI systems.

The architecture model considers two areas. It is a set of devices where certain types of software run, that surrounds or is worn by the person/user on his/her body and offers services related to his/her daily activities. It is divided into two sub-areas: Body, Immediate, Enhanced and Management area. The second one is the General, whose aim is to obtain external information, it is server side located.

Agents are the main part of the software that runs in each area. A MAS runs in each area, which controls the functionalities of the application or service of it.

Any AmI Space application can be implemented by using this model of architecture. When a new AmI Space application is designed, each part of the model has to be identified. This means identifying each MAS and its functions in the whole system.

2. Background

2.1. Ambient Intelligence (AmI)

The current ambient intelligence concept is the result of the evolution of Mark Weiser's concept, ubiquitous computing [1], and the vision of the ISTAG (Information Society Technologies Advisory Group) of the European Union, as one of the guidelines in the VI Research Framework Programme.

Mark Weiser was a researcher in computer science that created a new concept that was considered a new paradigm in computer science. Says Weiser [2]:

> *"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."*

When he says that technology disappears, he means that it is accepted by people without any effort and people

use it as a normal part of the life. The best example that explains this fact is that people, who wear glasses can see better, but they don't need to know anything about how the light pass through the lens.

The origin of the concept emerges from Weiser's observation of the importance of the computer in all aspects of daily activities. The computer instead of being an instrument to develop our activities that disappear from our conscience becomes the focus of our attention. This is not only a problem of user interfaces, but a problem of relation with the computers that surround us.

Together with computers, people would be able to develop in a more efficient and complete way all activities of daily life. Of course, a component of mobility must be added, to allow the user the movement in different space scenarios, and be able to develop any activity wherever he/she is. To do that, is necessary an underlying communications infrastructure with protocols designed for that purpose.

The ISTAG was set up to act as a consultant to the European Commission about the strategy to follow in Information Society Technologies (IST), and advice in the definition and implementation of a research policy in line with Europe. This policy must ensure that IST helps to improve the industrial competitivity and achieve the social challenges. In 2001, the Commission asked for a report to ISTAG, where they explain their point of view about Ambient Intelligence and its applications in the normal life of the European people in the year 2010 [3].

Ambient Intelligence (AmI) concept provides a vision of the Information Society where the total acceptance of the user is emphasized, support for more efficient services, user empowerment because of its use and support for human interactions. People will be surrounded by intelligent intuitive interfaces that are part of any object and by a physical environment able to recognize and respond to the presence of each person in a continuous way, non-intrusive and invisible.

The implementation of the AmI implies the appearance of a set of socio-political factors:

- It must make human relations easier.
- It must be oriented to the improvement of the society and the culture.
- It must help to create knowledge and skills for work, to have better quality of work and better choices as consumers.
- It must inspire confidence.
- It must serve people and must anticipate human needs, so it must be aware of the context of the people it serves.
- It must be bearable in the long term.
- It must be controlled by normal people, without the participation of technical experts for functioning.

Apart from this, some technological requirements must be taken into account to make real AmI:

Spaces with perception capacity and performance: people live and develop their daily activities in environments with a lot of sensors that are responsible to gather data of the observation of the person in the physical environment. The management of the "context-awareness" is one of the centers of attention in research environmental intelligence.

Transparency for the user: The user must not be aware of their existence or at least interact at a minimum.

Re-configurability: AmI must adapt to the context of the user. As far as possible the environment adapts to the user and not make the user adapt to the environment to receive the services.

Total mobility of the user and continuity of the service: The user will be able to use the services in any place where it is. If movement is necessary and there is not connectivity and another type of access is available, the communication will exchange with another type of technology in a transparent way for the user. The physical spaces will be able to interact with each other to obtain continuity of the service.

Learning: Environment with perception and computation capabilities is able to reason and learn based on the information gathered by phenomenon's occurred. Also, the environment is capable of receiving outside data, with the aim of perfecting its learning and its decision-making thereby informing the user when necessary and showing information in an appropriate way.

Intelligent access to the information: the system looks for the information that the user demands transparently. The system will be able to inform the user when it considers it necessary and to show the information to him/her in a suitable and coherent way with its context.

Natural and multimodal access to the information: the user will be able to use all the available resources to interact to his system. In any case it will be the most natural possible to the user based on its capacities and preferences.

Non-intrusive: this point is key to the acceptance on the part of the users of AmI. The system must be non-intrusive, which is to say that the user does not feel attacked physically or psychologically by its physical presence or its performances on him/her.

Security and control: the user must feel that he controls the system and that he can use it when he wants. The system must be safe from the point of view of reliability and from the point of view information privacy.

Once the AmI has been introduced it is necessary to make an approach to the architecture, which is the integration of all the individual elements of the technological requirements, making up an architecture that provides services to the user and adapts based on changes occurred in the environment.

AmI's challenge is to design an architecture where different current technologies are in use and is obtained an environment that changes dynamically, depending on the events occurred, taking coordinated decisions and carrying out the necessary changes.

2.2. Intelligent Agents

Intelligent agents cover a wide range of techniques and algorithms suitable for providing the functionality required within the AmI, where necessary in order to learn and take decisions in a dynamical way.

Inside of ambient intelligence, an intelligent agent is able to provide to users personalized services, and capable of anticipating their behaviour and therefore responding to their specific requirements.

There is no universally accepted definition of the term agent, but there is something widely used. An intelligent agent [4] is defined as one that is capable of flexible autonomous action to meet its design objectives. Being flexible:

Reactivity: To perceive and respond in a timely way to changes that occurs in their environment in order to satisfy their objectives. The agent's goals and/or assumptions that form the basis for a procedure that is currently executing may be affected by a changed environment and a different set of actions may need to be performed.

***Pro-activeness*:** Reacting to an environment by mapping a stimulus into a set of responses is not enough. Intelligent agents do things for the user, goal directed behaviour is needed. In a changed environment, intelligent agents have to recognize opportunities and take the initiative if they are to produce meaningful results.

***Social ability*:** Intelligent agents are capable of interacting with other agents (possibly humans), through negotiation and/or cooperation, to satisfy their design objectives.

Intelligent agents in AmI can be classified in two categories [5]:

Assistant agent: has its own user interface to communicate with the user and interact to him. This kind of agent may be called a proactive agent that tries to support the user while he is doing another task.

Hide agent: is an agent that works in the background decision-taking, and the user isn't aware of this. These kinds of agents are learning agents that use a knowledge base that enrich during the learning process of the agent. It's necessary to obtain information about user's decision to improve the knowledge base and improve the quality of decisions.

At this point, we must speak of Multi-Agent Systems (MAS), which are set of agents that interact among themselves.

Based on all of this information, it's possible to say that agent technology is a good tool to fulfil tasks behind the scenes transparent to the user (hidden agent), which only appear on stage when needed by the user (assistant agent).

3. Results

After carrying out a study on AmI, the properties that characterize it and that the agent technology that contributes to this one, there appears a model of architecture which proposes a division of the problem by areas, and where each of these is going to be managed by one o more agents, depending on the nature of the problem.

3.1. Model Description

The model of architecture has a modular design, which intends to facilitate the task of making an instance of a specific problem.

The model is divided into two main areas: Personal and General, which manages different types of services.

Personal: in which the environment of the user is encapsulated, it is to say that there are services where services technology required are situated in the daily environment of the user.

General: It is responsible for providing external information that is going to be used by all users of system.

In the next section, the sub-areas are going to be described in more detail.

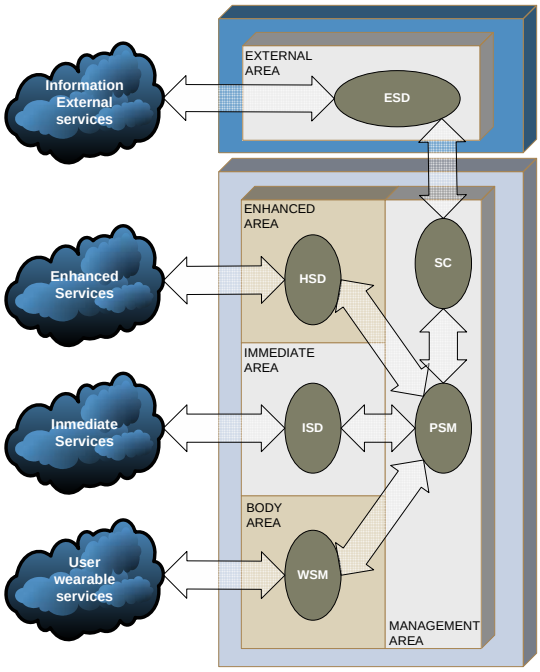

Figure 1. Architecture model based on Multi-Agent System.

3.1.1. Personal Area

Personal area is responsible for providing specific services to the user. Some of them concentrated in this area are going to interact directly with the user, which is why those in an assistant agent will be defined for such effect. However others will provide the user service transparent way, which is why they will be managed by hidden agents.

This area is divided in base on type of environment where is located. Sub-areas are the following:

Body Area: where the nearest services to the user, are contained for instance, sensors to take the heart rate. Each one is connected through a particular interface with the MAS denominated Wearable Service Management (WSM) that is set of hidden agents, and is the responsible for taking of decisions and learning based on the data collected of the sensors, that is to say control of the good behavior of the sensors as well as the user state.

Immediate Area: In this area, specific services are held, which gather data from the systems located in daily user Ami Spaces. The Immediate Service Dispatcher (ISD) MAS manage the information collected, also taking decisions and learning. ISD can be composed of hidden and assistant agents.

Enhanced Area: There are services that go with the user, that is to say, if the user is in his/her house it can benefit from a series of services that when leaving its house can continue using, since the necessary data is obtained from other external systems. The Enhanced Service Dispatcher (HSD) is the entity in charge to control these changes of environment to assure the availability of services. HSD also can be composed of hidden and assistant agents.

Management Area: This area takes charge to control the previous areas, and has a global vision of the Personal side. Personal Service Management (PSM) MAS formed by hidden agents that learn and take decisions about this side. When necessary, the PSM turns to Side Communicator (SC) MAS for help, which communicates with General Side to obtain information required.

3.1.2. General Area

External Area: This area integrates external services offered by other MAS, which can be localized on remote servers. External Service Dispatcher (ESD) MAS provide external services to the user, also it must be able to find new external services, by negociating with public MAS formed by hidden agents that allow one to make querys about your offered services, this implicates to speaking about compliant MAS [6][7][8].

3.2. Example

ASK-IT integrated project aims to establish Ambient Intelligence in semantic web enabled services, to support and promote the mobility of Mobility Impaired people, enabling the provision of personalised, self-configurable, intuitive and context-related applications and services and facilitating knowledge and content organisation and processing.

In order to be able to support the user in a holistic manner, ASK-IT focuses on geo-referenced and personalised transport and tourism services, which however are integrated fully to the home, work, leisure and sport, as well as the assistive technologies environments and devices. Emphasis is on seamless service provision, independent of the media, user location (i.e. indoors, outdoors, in a city, during a trip, etc.), user type and residual abilities.

3.2.1. Architecture

ASK-IT has defined a set of AmI spaces where great quantities of services are going to be integrated. These services are created separate from the platform. The user

can interact with the services via PDA, mobile phone or tablet PC.

To simplify the example and to make it more understandable, a reduced list of the AmI spaces and of the services is provided:

Description	Specification
AmI spaces	Home, car, enterprise, health centre, hotel and airport.
Services	Localization, navigation, health management, tourist and Leisure.
Devices	PDA, mobile phone, Tablet PC

From specification of the project it is possible to catalogue each service that is classified in any area of the model.

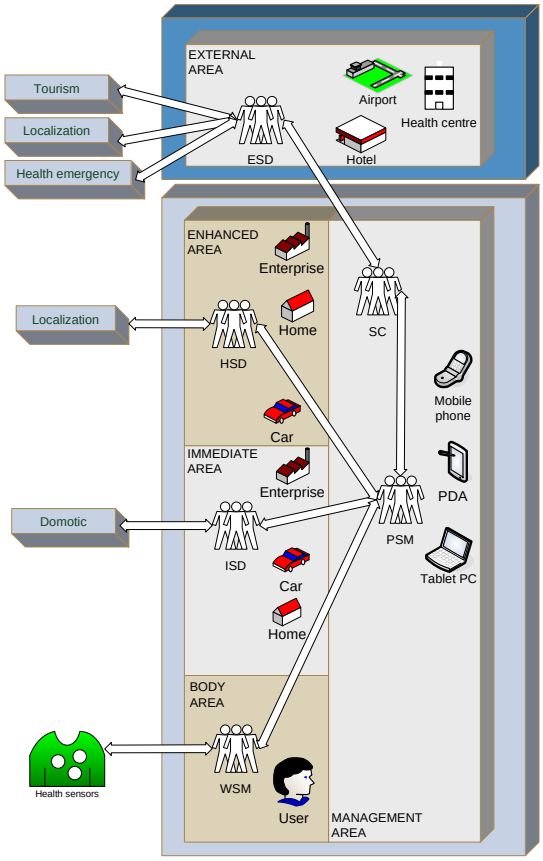

Figure 2. ASK-IT architecture based on model of architecture proposal.

ASK-IT architecture based on the model of architecture proposal is shown in the figure 2.

Now, several examples of services are explained in the next paragraph to see relations among all of components of the architecture.

Health management service is composed of some modules. In the Body area, are the health sensors, which gather heart rate data. Data are sent to WSM, which is responsible for deciding if data received are ok or must trigger a medical alarm at a health centre. Also it is responsible for detecting if sensors are ok or in contrast these are out of order, in which case must trigger an alarm to a user/nurse and then he/she must repair it.

When the medical alarm is triggered, the PSM must deliberate based on knowledge which it has. For instance PSM determine if the user is in a hospital, in your house, or in another outside place. In the first case, if the user is in a hospital, PSM would not do anything since it estimates that the user is going to receive medical assistance. In the second case, if the user is in his house, PSM would communicate with ISD or HSD having depending on which can offer the service of location of the user to him. In the last case, if the user is anyplace in which the service of location is not provided, for example in the middle of the forest, PSM communicates with SC. SC for of connection between both scopes, the Personnel and the General. After, ESD will negotiate with diverse MAS external to obtain the desired information.

4. Conclusions

In this paper, AmI characteristics have been identified. On the other hand, intelligent agents offer advantages and finally and on the basis of this, consider a thought model of architecture to be able to implant AmI systems. The architecture model is to modulate and allows being adaptation based on necessities.

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