

“Core Services” for Ambient Intelligence systems

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Abstract

“Core Services” are basic functionalities needed in an Ambient Intelligence (AmI) system that are not AmI themselves. They are traditional applications used in current computing systems whose functionalities are needed in an AmI system but need to be adapted to work effectively in this new scenario. There are also new “Core Services” that fit with non-covered technological needs.

This paper makes a brief description of the most important “Core Services” and enumerates their desired new features “colored” with AmI.

The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it [1].

When Weiser said that the technology disappears because it becomes part of our daily lives and we don't notice. We don't need to pay direct attention to the use of technology. The best example to illustrate this thing is for example, a person who wears glasses. He is able to see but don't know anything about the technology that is behind: only that he must wear them on the ears to see through.

The ISTAG (Information Society Technology Advisory Group of the European Union) was set up with the purpose of advise the European Commission in:

- Knowing which global strategy follow to carry on the thematic priority of IST.
- Orienting the European Research Area, stimulating the European research Communities.

The Ambient Intelligence concept provides a vision of the Information Society in which the total acceptance of the user is emphasized, the support to more efficient services and the user empowerment. People will be surrounded by intuitive intelligent interfaces that are widely distributed among all possible objects and the physical environment able to recognize and respond to the presence of the person in a continuous, non-intrusive and invisible way.

AmI should foster the following human factors. AmI should:

- Make easier the human contact.
- Be oriented to the empowerment of the society and the culture.
- Help the building of knowledge and the skills for working.
- Inspire confidence
- Bearable in the long term

1. Introduction

This article describes the concept of an Ambient intelligence core service. First of all, there is an introduction to the concept and the social implications of the Ambient Intelligence that is the application of a paradigm in which the person is surrounded by invisible technology not to his eyes but to his mind. Then, it is analyzed which are the most important parts of an ambient intelligent system: “Core Services”. These are horizontal services needed by the AmI paradigm to ensure all the services that promises: localization, service discovery protocols, intelligent and natural user interfaces, context-awareness, and seamless connectivity. For each, core service there are identified its main features and also the expected features needed when working in an ambient intelligence technological environment.

2. Background

Mark Weiser is considered the father of what is currently known as Ambient Intelligence (AmI). He created the concept in 1991 calling it Pervasive Computing or Ubiquitous Computing.

- Controllable by normal people without the intervention of technical experts to work.

Technological requirements that should be taken into consideration are [9]:

- Non-intrusive hardware.
- Continuity in the mobile and fixed Communication Infrastructure.
- Dynamic and massively distributed networks of devices.
- Easy and natural to use human interfaces.
- Security and reliability in the realization.

Technological fields that apply in the AmI field are the following:

- Distributed systems, hardware and middleware: set of areas related to distributed information systems, non-intrusive hardware such as sensor networks and light weight devices, and low level software or middleware.
- Communication networks: used to transport all the information related to the intelligence of the system between the different physical parts of the system. Push the information wherever the user is located.
- Artificial intelligence techniques: set of algorithms that puts the intelligence in the system. Also to represent and manage the knowledge of the application domain.

Finally, “**Ambient Intelligence**” is known as the set of technologies that surrounds the person in an invisible, non-intrusive way, without physical or psychological constraint over him/her, where and when needed, and that provides multiple services having the aim to cover all the possible needs in a proactive way and enrich his/her daily life.

3. Core Services

The “**Core Service**” concept was invented by TSB-ITACA group, and it is a basic functionality needed in AmI system that is not AmI itself, that is totally integrated in an AmI system.

They are parts of the AmI system that other core services or other parts of the system use. They can be

- Traditional applications whose functionalities are needed in an AmI System, but must be adapted to work in new scenarios. Localization techniques are going to be described as a Core Service. Localization of people and resources has been a problem itself in the ICT research field. Ambient Intelligence paradigm takes with it the necessity to have a localization subsystem to locate people in the several environment and spaces where AmI

services are offered. This adds new functionalities or needs for the localization in the scope of an AmI system.

- New Core Services (functionalities) that appear as a consequence of the new paradigm.

Core Services that will be described in this paper are:

- Localization.
- Service Discovery Protocols.
- Intelligent user interaction.
- Context-awareness unit.
- Seamless connectivity.

There are other core services waiting to be discovered in the process of research in AmI. Other core services are waiting to be adapted from the current state-of-the-art.

Security and Identification and Session Maintenance are considered core services but are not described so deeply in this paper.

3.1. Localization systems

3.1.1. Definition and current features. To deliver ambient services to a person in a proactive and preferred way, it is indispensable the presence of a location system in those spaces where the user can be present.

Basically, there are two types of techniques to identify a person in a concrete place [5]:

- Using specific wearable devices that advise through the emission of a communication signal to a high level system that knows then where the device is. It is supposed that the user and the device always go together.
- Not using any wearable device: it is the ambient which is a combination of sensors and logic, who identifies the person.

A third technique not mentioned is the combination of both systems, but it requires the existence of a high level entity that analyzes the data that come from them and put together to empower the location system results.

In one hand, an example of the first technique, usually more extended in in-door location systems, is a wearable device with a wireless communication interface (Bluetooth or ZigBee are widely extended) and a set of beacons distributed in the environment. Each beacon interchange some data with the device with a certain level of transmission power: the location can be calculated making mathematical operations with the power used in the transmissions by each peer of beacon-device: i.e. the reception of the highest power signal by a beacon means that the device is in the

coverage area of that beacon. These mathematical operations can be more complex to improve the accuracy of the localization system. Other techniques similar to this are based on the use of RF-ID tags. These are small and simple devices and very often without power source called "Tags". They are composed by a small memory that stores an identification number and an antenna that is stimulated by an external electromagnetic source called "Reader". This stimulation brings on the emission of the identification number within a short range area and received by the reader. The most complex part of the system is how to stimulate the tag what implies the distribution of readers across all the spaces.

There are also several localization system for outdoors environments based on the use of a device with a certain level of intelligence. GPS localization systems and localization inside a cell in a mobile phone cellular system are two examples of it.

On the other hand, there are systems that discover the position of a person but the person does not wear any device that alerts about it. The first step for the system is to conclude that there is a presence in a concrete position or room. Then, this presence must be identified. The first part of the system is usually covered by ambient sensors widely distributed that detect basic events such as "there is movement", "this door was opened" or "a tile on the floor detects a weight". Once, the system knows there is a presence in a point it must be identified. The identification process can be made by the use of cameras and the further analysis of the video signals. Since, the treatment of video demands computation power, there are already several techniques of identification of people with low demand on computation and memory power. Without the use of cameras it is possible to identify a person by other personal parameters such as the sound he makes when walking, behavioral patterns, and anthropometric parameters.

The first technique has the advantage that the calculation of the position is more accurate since there is information given by the wearable device. In opposition the use of a wearable device make the location mechanism not as natural as desired to cover with ambient intelligence requirements from the user point of view. There is also a problem with wearable devices (this does not happen using passive RFID Tags): the power consumption makes necessary the use of a battery what implies heavier devices and bigger, what goes against "invisible technology". Finally, the position of the person is the position of the wearable device. This does not work if the user abandons the device.

In the second case the system is not so accurate since there is any element able to transmit data related to he position or to identify it. It is necessary to have higher memory and process capabilities to make more calculations with heterogeneous data. Though, it has the advantage that it is a non-intrusive system. Some people don't agree with it since people localized with this system are not aware if they are being localized or not, or at least, they can't control when to be identified or not.

3.1.2. Desired features. An ambient intelligent platform, that covers as many aspects of the daily life processes as possible, demands the following features:

- Creation and use of Ambient Models. These are logical representations of the spaces where the user may receive AmI-services. They are useful for the treatment of location and presence information by the different components of an AmI-system. These Ambient Models can be enriched by the addition of tracking information to model the user's behavior in terms of mobility. This will make possible the interrelation and management of data among different types of heterogeneous location systems with different accuracy, amount of information or range of coverage.
- New location technologies and logic: the combination of technologies of localization based in non-intrusive techniques but controllable by the end-user and based on wearable devices really thin and light. The calculation of data continues being so important than in the second case, but the income of data from several sources make the method more reliable.

3.2. Service Discovery (SD)

3.2.1. Definition and current features. Service discovery enables devices and services to properly discover, configure, and communicate with each other. When a user enters in a room the invisible set of devices that surrounds him/her communicates one with each other in order to find the set of services to be offered by the ambient to the user. Perhaps the user wears a personal device with him through which services are offered. This device will implement a service discovery protocol that ask for services to the ambient and negotiates their parameters.

There are three main protocols widely extended when talking about SD: Jini, UPnP, and Salutation.

The purpose of the **Jini** protocol is to federate groups of devices and software components into a single, dynamic and distributed system [3]: printers,

disks, software applications, files, users... The core of the Jini system is a trio of protocols working together: "discovery" and "join" that are executed when a device is plugged-in the system, and "lookup". Discovery occurs when a service is looking for a lookup service to register. Join occurs when a service detects a lookup service and wants to join it. Finally "lookup" occurs when a client or user needs to locate and call a service described by its interface type written in Java. The Lookup service can be seen as a directory service where services are published and found. In a Jini community, services register their proxy objects through a discovery/join process, and clients query the lookup service to find out the services they want to consume.

Universal Plug and Play (UPnP) is an architecture for peer-to-peer network connectivity of intelligent appliances, wireless devices, and PCs [3]. A device can dynamically join a network, obtain an IP address without using DHCP, communicate its capabilities when requested, and learn about the state of other devices. A device can also leave a network smoothly and automatically. SSDP (Simple Service Discovery Protocol) is used for announcing device's presence to others as well as discovering other devices or services. In some way, it has the same role as discovery, join and lookup in Jini. SSDP uses the TCP/IP stack: HTTP over multicast and unicast UDP. A service that wants to join sends out a "advertisement" multicast message to control points, that are the potential clients of services embedded into the device. This message contains a URL that points to a XML file in the network, where capabilities of that device can be described in a very powerful way. Opposite to Jini there is no central registry to look for in. When a new control point is added to the network it sends a "search" multicast message. Any device that hears it should respond to it with a unicast message.

Salutation is an architecture for service discovery among appliances and equipment in a connectivity and mobility environment [3]. It has been thought to work with a wide range of devices. Therefore, it is independent on the operating system or the communication protocol. This architecture makes possible that applications, services and devices can search other applications, services or devices to ask for particular capabilities, and to establish communications between them to consume them. The architecture is composed in one hand, by the Salutation Manager. It is a service broker. A service provider registers its capabilities through the Salutation Manager. When a client ask its local Salutation Manager for a service search, the different Salutation Managers coordinate to

do this search and provide the contact to the client to use the service. On the other hand we have the Transport Manager that provides reliable communication channels to the Salutation Managers independently of the underlying transport protocols.

Currently, Service discovery protocols are widely extended in home and enterprise environments, but they don't fit so well for new scenarios of Ambient Intelligence. Fortunately they are designed to minimize administrative overhead, increase the usability. They are a good starting point to have an Ambient Intelligent version of such protocols.

3.2.2. Desired features. Most challenging features for service discovery in ambient intelligence environments are the integration with people and the integration with different environments [4].

In the first case, people's digital information can be communicated over several networks or inferred as a result on lectures on sensors. Here there is a security issue to research on: how ensure that data don't fall on bad hands.

A person can take two roles: user or service provider. Many protocols are used for the communication between software entities and therefore they use standardized names and attributes what helps to minimize ambiguity. But users have to deal with these issues and they are not going to learn machine languages. It is desirable that service discovery mechanisms would be easy to use by normal people in a natural way. It is a shared problem with the user interface experts.

The identification and credential management is a challenge in services discovery and in ambient intelligence systems in general. Service providers in an ambient intelligence environment coexist at the same place. Users, that are service provider, are not going to provide their login, password and domain to receive services or publish them in that place. New models of system logging are needed to be able to manage with service providers, consumers and who have permission to provide or consume. Relations can be really complex.

Talking about the integration with various environments it is desirable that service discovery instances know exactly how to manage with the targeted environment o environments.

Current service discovery protocols have heterogeneous capabilities oriented to different goals and solution. Therefore, taking a single protocol and adapting it to the AmI paradigm won't be the solution. It is desirable to have a common platform that ensures interoperability among SDP's and try to use all the

power we have available today, oriented to solve our environmental problems.

3.3. Intelligent User Interaction

3.3.1. Definition and current features. Human-computer interaction (HCI) is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them [6].

User interaction is becoming the most important feature in ambient intelligence system. User interaction can be divided into user psychological, affective and functional behavior with the system, and the techniques to push information to the user and take information from him/her.

We can describe the current features of the HCI divided in several fields:

- Input and Output Techniques: input techniques based on two dimension systems and on obsolete devices such as mouse or keyboards. Voice and dialog recognition techniques need that a computer with advanced capabilities in process and memory executes it to have good results and high percentages of success in the understanding of orders or commands. Ambiguity in the sentences made by human is not well understood by voice recognition systems. Gesture recognition systems are at the very beginning stage of research.
- Software and intelligence:
 - o Dialog control: simple interactions already pre-defined based on windows, buttons, clicks...
 - o User modeling: limited models of user's representation.
 - o Programming APIs: inexistence of an underground common logic to program user interface functions.

3.3.2. Desired features. Ambient Intelligence deals with the use of invisible technology to achieve some goals by the user. It means that user interface is the frontline of this invisibility. Independently on the chosen techniques to compose real interfaces and interaction techniques they should be as natural and easy to use as possible: invisible.

- Natural interfaces. Easy to use and intuitive, without learning curve. Use of Multimodal Interfaces: are interfaces where there are several ways of exchange information between a persona and a machine and take place at the same time. For instance, using the gesture language and the spoken language in a simultaneous way. The person

always uses several resources to communicate intention and emotions to other person. It reinforces the machine decision process. It is a richer way of relation with an Ambient Intelligence system.

- New models of dialogs between the user and the system. Less ambiguity in the interpretation of data coming from the person. It is a success, if the user interface motivates the person to use the system. Motivation is one of the most important issues in user interfaces applied to Ambient Intelligence.
- New metaphors and devices: daily devices with intelligent behavior. Abandon of monitor-based graphic interfaces. Some examples of new devices and ways to represent information can be seen in products of "Ambient Devices" company [7]. Intelligent Agents in User Interfaces management.
- Affective computing: computing that relates to, arises from or deliberately influences emotions.

3.4. Context-awareness unit

3.4.1. Definition. The context-awareness unit inside a system is a new concept that arises from the paradigm of AmI itself. "Context" in AmI deals with any information that can be used to characterize the situation of an entity. An entity can be a person, a software application running, a certain room...

A context-aware system is an intelligence system that uses the context information. This information must be represented in a language intelligible by machines. Context-aware systems are used in environments where decisions are taken. In the case of Ambient Intelligence this unit is located in the core of the system.

A context-aware system receives data from heterogeneous sources and also can produce some new knowledge as a result of an inference process using previous input data.

When talking about AmI context-awareness is more focused on the user, the human person. The context information of a human being can be classified in a huge amount of categories: Physiological, spatial, environmental, organizational, social, emotional, preferences, temporal, history, computational... Therefore the heterogeneous amount of data can be taken from analysis of the physiological state (wearable health sensors), presence sensors and behavior modeling, where the user is, what does he/she made in the past hours, what is expected is going to do (agenda), how is the agenda of people that the person have contact with, which are the user preferences, how

is the weather today and how does it affect to the user...

3.4.1. Desired Features. In this section is not expected to have current features since it is a new concept that is currently being researched by the scientific community.

- Context-awareness Unit's results are the input for other parts of the intelligence of an AmI system. A knowledge based system can demand some information from the context-awareness unit, and it must provide it in a common and standard format.
- Context normally increases the bandwidth of the communication between people. It has the same implications in a AmI system. The more quantity of information the context-awareness unit can manage the better decisions are taken for the knowledge based system it feeds.
- The management of the context should be invisible to the user. Maybe the user does not know which information is useful or not.
- The problem of showing context-related information to the user is limited not by the processor power or memory size, but by the capacity of the human attention. It is a challenging issue for researchers in the field of human interfacing.

3.5. Seamless Connectivity unit

3.5.1. Definition

Seamless connectivity deals with the continuity of communications availability while the person moves. It is a set of functionalities regarding communication needs in an Ambient Intelligence scenario which objective is to make transparent the use of the network, and which type of network is needed to the end-user.

For example, an old woman that wears a personal device that manages all aspects related to her mobility. When she is at home, the device uses the wireless connection that she has there, to know which are the bus schedules to go to see her grandson. When living home she arrives at the bus station and the Bluetooth network in the building is offering her some services related to her trip. Then she arrives at destiny but there is no Bluetooth or WiFi connection there. The device uses the coverage of the 3D network to get information about the route to follow to go to his grandson home.

In a practical approach, seamless connectivity is a Middleware solution that manages all the communication interfaces of the environment. It uses context information in order to decide, which is the

best method or network interface to connect and acquire information.

But this is an issue not only associated to personal devices. Also the Network Operator or Provider has its own processes to enable seamless connectivity for the user.

3.5.1. Features

- It ensures the continuity in communications, and therefore the continuity in the service delivery.
- The user has some policy to access networks.
- The user does not need to be an expert on communications.
- Seamless connectivity ensures that networks resources are not wasted.

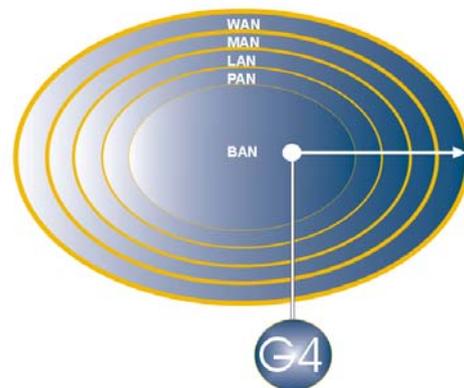


Figure 1: Seamless connectivity: beyond 3G?

3.6. Other Core Services

Identification and the management of session techniques are necessary to maintain the user in the system and relate the actions he/she is doing and the internal workflows and control of time. Knowing when a sensor has detected a threshold in relation to a person is not an evident problem to solve.

Security is another core service that should be distributed along all parts of the system. Thinking in the definition and social factors of ambient intelligence, security becomes a key issue in the process of making real the AmI paradigm.

4. Conclusions

The main conclusions of this core services analysis are:

- First steps in the research of ambient intelligence core services are promising, in the analysis of old technologies applied to the new paradigm and also in the identification of possible functionalities not covered with current subsystems.

- New environments are not tested enough. For the present all these systems are only working in prototypes or in controlled environments under laboratory conditions. Human needs are still pending to be analyzed while working daily with these types of systems.
- It is foreseen that European Framework Program 7 in IST will be the research program on ambient intelligence.

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