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Ambient Intelligence, from the Vision to Reality. Perspective of a Telecom Operator

Rodrigo González-Martínez

This article, beginning with a brief introduction to Ambient Intelligence, focuses on the perspective of a telecom operator, particularly on Telefónica's vision of the Digital Home. Digital Home is presented here as an element for filling out Ambient Intelligence and some related concepts are also introduced. Next, a set of enabling technologies will be generically identified. These technologies will be the key for allowing the creation of Ambient Intelligence scenarios in the near future. Finally, a series of innovative projects are presented currently under development and involved in Ambient Intelligence technologies and concepts.

Keywords: Ambient intelligence, AmI, Digital Home, Digital Personal Environment, Domotics, IAm, Intelligent Environments, Telefónica.

1 Introduction to Ambient Intelligence

"We believe that, in the year 2020, people will relate to electronics in more natural and comfortable ways as we do now". With this sentence, Philips exposes its vision of Ambient Intelligence [1]. Although it was already in the eighties when some concepts related to Ambient Intelligence started to be used and implemented, it is in 1999 when a group of experts from Philips developed a first report including the definition and scenario for Ambient Intelligence [2].

In an Ambient Intelligence scenario, technology and persons coexist harmoniously; technology is at people's disposition in a transparent way, facilitating every daily home task. Technology underlies the execution of such tasks, however the user does not realize its existence, s/he just uses it in a natural way and notices its benefits. Pictures that change their contents depending on the mood of the person, daily objects that change their appearance in order to highlight events, the possibility of watching on television pictures allocated on a mobile phone by just approximating them, home (light, climate, sounds, etc.) adaptation to the inhabitants preferences or interaction with the environment via voice, gestures or by just doing nothing (implicitly). These are some examples of what Ambient Intelligence is.

Ambient Intelligence is not a technology by itself, but a concept, a vision that will become possible in the near future thanks to the development of technologies in different fields such as ubiquitous computation; wireless communications; miniaturized embedded devices; ambient and biometrical sensors; intelligent systems able to learn, predict and anticipate; multimodal natural interaction, or adaptive systems [3].

The main application field for Ambient Intelligence is the home and, by extension, the digital personal environment, namely the set of environments that surround the person in the development of his/her daily activity: home, ve-

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hicle, office and his/her own personal environment with his/her portable devices.

2 Ambient Intelligence Vision of a Telecom Operator

The vision of an integral telecom operator is the availability of permanent connectivity with a bandwidth enough for both the home (fixed network) and the moving person (mobile network). Beyond connectivity, the problem is posed of ubiquitous access to services, with the available connection, from the available device, with the available capabilities and in the best consumer conditions possible. The focus will be the person and the different environments in which his/her daily life is developed (home, vehicle, work, mobility), always connected and able to access to services.

Digital Home, seen as the scenario for the convergence of broadband communications, computers and personal assistants with capabilities for information processing, digital content and fixed and mobile electronic devices that perform specific functions, shows up as a favourable environment in which Ambient Intelligence scenarios can be developed. If we add to the Digital Home scenario the feature of ubiquity that provides connection whilst mobile, Ambient Intelligence scenarios can be notably enriched.

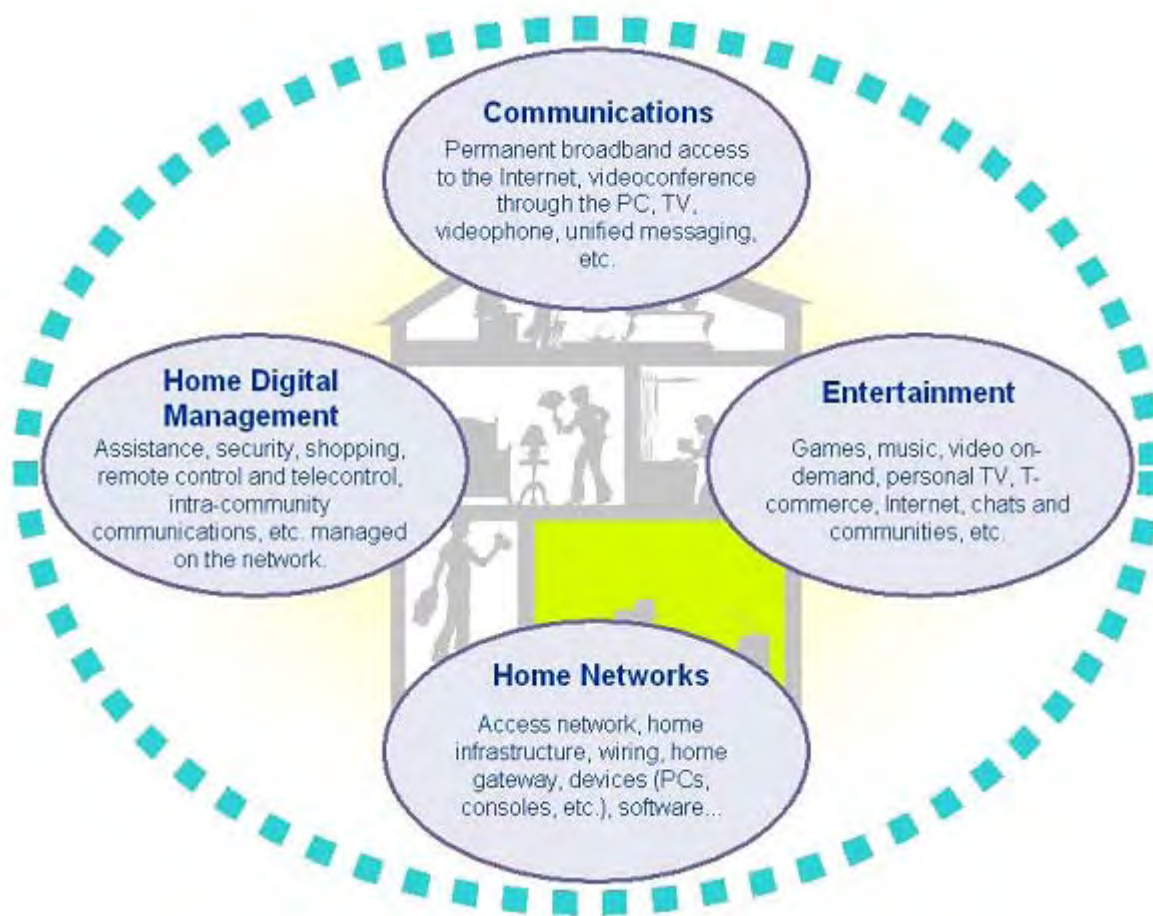


Figure 1: Real Convergence of Sectors in the Digital Home.

Next, the Digital Home is described from the point of view of the telecom operator. In this scenario, the operator plays a key role in provision of home services and in mediation for the provision of services by other providers [4].

3 Digital Home as an Enabler of Ambient Intelligence

Digital Home is the first scenario in which the long-announced aspects of the telecommunication, multimedia, informatics and consumer electronics sectors will converge at a commercial level. In the scenario of the Digital Home, we can find a generalized availability as well as a low cost of the following elements:

- Broadband communications.
- Digital contents.
- Devices that join great features for storage, communication and digital contents processing.
- Computers and personal assistants.

All these create the Digital Home as a "battlefield" in which a competition between the main informatics, consumer electronics, Internet services providers and entertainment companies, and even the big distribution chains, will take place. Other traditional home players, such as energy suppliers, household appliances, security and surveillance

enterprises or health and assistance service providers will also fight for establishing a "digital position".

Technologies and markets are already mature enough to provide a new scenario of threats and opportunities for the Telecom operator, who will be pushed to define its role in this new scenario.

3.1 Context and Opportunity for a Telecom Operator

The Digital Home context in developed countries is the one of an explosion of the terminals and devices within the local home connectivity market (the average annual consumption per home of consumer technological devices in USA is estimated in 1500US\$), as well as a wide deployment of broadband connectivity.

On the other hand, mature technologies and numerous market products (communications, consumer electronics) are available, at the same time that there is wide participation and agreement in the standardization forums.

All these features open a window of opportunity for the Telecom operator, in which the new Digital Home is not something unconnected with the operator, not the exclusive competence of the users (that were separated until now by the "network endpoint"), but it becomes a natural place

for network growth, adding connectivity, guarantee and quality of service to the new home devices and simplicity in the acquisition, use and update of user services.

3.2 The Digital Home scenario

Figure 1 represents the functional components that constitute the Digital Home.

Home Networks are the communication infrastructure at home, both wired and wireless. These networks are, at the present time, differentiated for each digital home service category. Thus, we can talk of a domotic network, an entertainment network and a data network. A key component of the home network is the home gateway that allows the different networks to interact with each other as well as with the outer world.

Home Digital Management allows the improvement of the comfort and security at home, enabling services such as technical detection alarms (gas, water, fire...) and their remote management, remote control of air-conditioning, illumination, blinds and awnings, swimming pool control, watering automation, intruder detection or simulation of presence, remote security, video vigilance, remote assistance...

Entertainment devices and services are the most widely and fastest adopted by the home consumers. Services for gaming, digital TV, digital pictures, music streaming, video and music on demand, PVR (*Personal Video Recording*), EPG (*Electronic Programming Guide*), interactive advertisement, etc., are all possible, to a great extent due to the very fast adoption of consumer electronics devices in the home environment. There are some devices already available in the market that allow the connection of audio and video devices to the home PC (in a wired or wireless way), enabling the direct access to on-line contents.

Communications are also a fundamental component of the Home Digital scenario. Adoption of broadband at homes allow not only Internet access with a higher speed, but also new services such as videoconference, video-phoning or instant messaging, as well as the option of connecting online many of the aforementioned entertainment and management services.

3.3 Examples of Services at the Digital Home

Next, we gather some examples of possible services on the Digital Home infrastructure provided by the operator:

- Communication services: voice, voice over IP (VoIP), IP videoconference, unified SMS messaging, instant messaging, etc.

- Home remote managing services: domotic remote managing (air-conditioning, lights, automatisms...), technical alarms management (gas, water, fire...), video remote supervision, remote vigilance...

- Personal services: device sharing, personal content (pictures, video...) sharing...

- Extended home or homes networks, meaning a virtual environment of interconnected homes in which services, devices and content are shared.

- Professional services: remote social or sanitary assistance, teleworking, teleoffice, remote maintenance, etc.

- Contents and information access services: Internet, online shopping, online content...

- Security services: Firewall, antivirus, antispyware, parental control...

- Digital leisure: Television on demand (IPTV), PVR (*Personal Video Recording*), online games, etc.

4 Some Enabling Technologies for Ambient Intelligence

4.1 Fixed-mobile Convergence and Unique Network "All IP"

For an integral telecom operator, the future of the network shapes as a package commutation network, in which all the traffic of voice, data, TV, etc. travels over IP. Mobile and fixed networks converge in a single network and services are offered end to end, taking advantage of the network capabilities (identification, session continuity, localization, quality of service, etc.), but abstracting from the underlying transport network. The telecom operator offers network facilities that can be used by service providers, becoming this way a key player in service providing.

Several initiatives for 3GPP IMS (*IP Multimedia Subsystem*) [5] and ETSI TISPAN (*Telecommunications and Internet converged Services and Protocols for Advanced Networking*) [6] are in charge of standardizing this unique network.

4.2 Service Gateway

Service gateway is an element that links the operator network with the home networks and devices. It is an evolution of the network endpoints or residential gateways that, as well as interconnection, routing and network interoperability features, adds advanced features for deployment and remote management of services by both the operator and third party service providers. The service gateway is an element controlled by the Telecom operator and it can be the key for the incorporation of new services in the home environment, managing parameters such as quality of service, security or the unique identity of a user in a unique fixed-mobile network. HGI (*Home Gateway Initiative*) is the forum in which the components and functions that are expected for a Service Gateway are defined [7].

Another function of the gateway is to ensure access to the different networks and devices located at home, guaranteeing the interoperability between home networks (Ethernet, Wi-Fi, Bluetooth, PLC, domotic networks); WAN networks (xDSL, WiMAX, FTTx fibre, etc.), and fixed-mobile convergent networks (Femto-cells, UMA, DECT, CAT-iq, etc.).

Typically, the gateway executes a middleware that offers the applications the necessary functions through standard interfaces. This middleware may constitute the key for the deployment of home services on the infrastructure provided by the operator.

An interesting concept for Ambient Intelligence is the mobile gateway linked to the person, that is to say the mobile device itself acts as a gateway towards other devices or

services in the personal environment. Some illustrative applications may be continuous remote monitoring of biometrical constants, or the information update in a vehicle's navigator.

4.3 Provision and Remote Management

From the point of view of the Telecom operator, massive deployment of services and their subsequent management and maintenance must be systematically and automatically performed and, for this, mechanisms for providing and remote management are indispensable. Initiatives by the DSL Forum [8] and OMA (*Open Mobile Alliance*) are in charge of defining standards for provision and remote management, both TR-069 for network and home devices remote management and OMA DM (*OMA Device Management*) for mobile devices [9].

For the deployment and remote management of services on the Service Gateway, OSGi (*Open Services Gateway Initiative*) defines a reference framework [10].

4.4 The Universe of Electronic Devices around the User and the Home

Nowadays, the proliferation of electronic devices around the user and the home (TV, DVD, decoders, Home Cinema, e-PC, laptops, PDAs, mobile phones, video cameras, MP3 players...) is a fact. As we get surrounded by more and more of these devices, the complexities of connection and configuration grow, the responsibility falling nowadays on the user for keeping them operative. Another fact of current devices is that they are "autistic" (independent, isolated), their connection capabilities are limited and their capabilities for understanding other devices are almost inexistent. This situation must be resolved in an Ambient Intelligence scenario:

- Abstracting the user from the technology complexities, the user must only notice the benefits of the technology. The user doing nothing is the ideal to be achieved, "zero-touch", real "plug&play".
- Automatically discovering new devices, their features and functions.
- Ensuring interoperability between electronic devices, both domestic and personal.

There are several initiatives oriented to solve this series of problems, such as DLNA (*Digital Living Network Alliance*) [11] oriented to the interoperability between devices and digital contents or UPnP (*Universal Plug and Play*) [12] for automatic discovery of devices and services.

4.5 The Ubiquitous Access to Services and Digital Content

In a scenario of Ambient Intelligence, we raise the ubiquity in service access and content. Access to the wanted service or content, with the means available at that moment for ensuring the best consumer quality possible.

The former statement has numerous technological implications that are not all currently solved. Let us analyse some of them:

The available broadband. It is feasible that the broadband availability changes, for example depending on

whether I am using a wide-band connection at home or a mobile connection. A circumstance that should not deny the access to services, but can restrict the enjoyment conditions.

The capabilities of the available device. This circumstance can restrict the enjoyment conditions of a service or content, but the service should be conscious of such limitations and adjust to them. For example, I can proactively adapt a high definition content in order to visualize it within the definition of my mobile terminal, optimizing at the same time the consumption of broadband.

Content adaptation. It can be necessary to adapt certain content to the consumer conditions (broadband, terminal, format suitability, etc.).

Service adaptation to the available capabilities (adaptive services). Services must be able to fit the available capabilities, keeping their availability even if that implies limitations.

Adaptation of the available interfaces (adaptive interfaces). Services interfaces must have the ability of fitting the available capabilities, keeping the functionality of the service.

Roaming between networks. Access to services must be kept even when we change from one network to another, a circumstance that ideally should be transparent for the user.

Portability of services. Services go with me; they come along with me in my digital environment (home, office, vehicle or personal in mobility).

4.6 "Intelligence" in Applications

In an Ambient Intelligence scenario we will also have to integrate technologies that give the feeling that applications work with a certain level of intelligence. Some key features for this can be the following:

Gathering and exploitation of context information. It is feasible to obtain information of the user environment that can be useful for the applications, either because it can be explicitly monitored with sensors or because it can be obtained by means of processing the available information (available resources, preferences, common actions, etc.).

Personalization. Services can be offered in a personalized way for each person and circumstance. Available information (profile, context) will be the key for performing good personalization.

Advanced interaction. System interfaces must evolve. Multimodal interaction means a big advance, but implicit interaction, having the user doing nothing expressly, opens a lot of possibilities. Wireless technologies of proximity, such as RFID (*Radio Frequency Identification*) or NFC (*Near Field Communication*), open some new possibilities for interactions with systems.

Intelligence, prediction, anticipation, reasoning. We pose that applications will progressively incorporate skills to seem intelligent. Skills such as prediction of user actions, anticipation of them or taking consequent decisions are some aspects that we can relate with intelligence.

Current trends that will allow a certain degree of intelligence in applications aim at the semantic characterization based on ontologies (of contents, terminals, environments,

Project	Web Site	Aml Technologies involved
AMIGO (<i>Ambient intelligence for the networked home environment</i>)	< http://www.hitech-projects.com/euprojects/amigo/ >	Interoperability networks and devices Middleware. Devices Discovery. Contents Discovery. Context Management. Advanced interaction (gestures, voice...).
TEAHA (<i>The European Application Home Alliance</i>)	< http://www.teaha.org/ >	Interoperability networks and devices Middleware. OSGi services gateway. Services Discovery. Deployment and remote management of services.
SMARTTOUCH (<i>Browsing Through Smart Objects Around You</i>)	< http://www.smarttouch.org/ >	"In touch" advanced interaction, proximity interaction. Linking between physical objects and the virtual world (systems).
EnComPAs (<i>Enabling Community Communications – Platforms and Applications</i>)	< http://encompas.org/ >	Deployment and remote management of services. Remote management of devices and networks at home. OSGi services gateway.
AMEC (<i>Ambient Ecologies</i>)	< http://www.amecproject.com/ >	User-centred methodologies for designing, developing and validating Ambient Intelligence solutions.
ePerSpace (<i>Towards the era of personal services at home and everywhere</i>)	< http://www.ist-eperspace.org/ >	Personalization of services. Exploitation of user profiles and context. Ubiquity in services access.
MONAMI (<i>Mainstreaming on Ambient Intelligence</i>)	< http://monami.info/ >	Ambient Intelligence accessibility for everybody. Ambient Intelligence suitability for aged people or people with disabilities.

Table 1: Ambient Intelligence Projects in which Telefónica R+D is actively involved.

etc.). A semantic reasoning will be able to be performed over those ontologies.

5 Ambient Intelligence, some Practical Experiences

From *Telefónica Investigación y Desarrollo* (Telefónica Research and Development), we are actively participating in the development of ambient intelligence technologies that will allow new applications for the home and digital personal environment.

In Table 1, we refer to some projects, important due to their innovative character and expectations. In order to obtain further information, you may visit the web sites of any of these projects.

6 Conclusions

In this first decade of the 21st. century, the technological bases that will allow the creation of intelligent environments in the near future are being set up. In this decade numerous enabling technologies for ambient intelligence are being developed and they already allow the creation of ambient intelligence scenarios, such as the ubiquity in communications, the proliferation of connected devices with processing capability, evolution of sensors and actuators or advanced interaction with systems. However, we believe that there is still a phase of technology harmonization left

that would allow these technologies to be easily accessible for users. This is a challenge that should be tackled in the next decade so that ambient intelligence can become a daily reality.

The role of the telecom operator appears to be fundamental in this new scenario of ambient intelligence, specially the one of the integrated operator of fixed and mobile communications, which allows the extension of ambient intelligence beyond the home environment towards what we called the digital personal environment of the person (vehicle, office or person in motion). In both environments, the telecom operator sets itself up, beyond only being the supplier of broadband connectivity, but as the key for the provision of services in the home and personal services by means of growing as a mediator in the provision of services and guaranteeing such aspects as quality of service, ubiquitous access, user identification or security and privacy in communications from the network itself.

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