Report on the impact of technological developments on eAccessibility

February 2008

••• **Design for All for eInclusion project**

Project Number IST CA 0033838

Project Acronym DfA@eInclusion

http://www.dfaei.org/

Deliverable D2.1

European Commission
Information Society and Media

e-inclusion
Be part of it!

Editors:

Pier Luigi Emiliani	(CNR)
Laura Burzagli	(CNR)
Marco Billi	(CNR)
Francesco Gabbanini	(CNR)
Enrico Palchetti	(CNR)

Executive summary

The purpose of the deliverable is to discuss the present situation and the possible impact of the ongoing technological developments in Information and Telecommunication Technology (ICT) on the inclusion of people with activity limitations.

It is based on the main assumptions that: (i) the correct definition of eInclusion is the one published in the 2006 Riga ministerial declaration[1]; (ii) adaptations through Assistive Technologies (AT) are not sufficient to capture the potentialities of ICT in supporting people's inclusion, but a shift toward the "Design for All" (DfA) approach, based on the conceptual principle that all users must be taken into account in the design of new products and on suitable technical approach(es), is necessary; (iii) the European society is migrating toward an information society, described by the Ambient Intelligence (AmI) paradigm; (iv) there will be a (long) transition to a complete AmI implementation, when many inclusion feature will be included in the mainstream developments; (v) and, therefore, the Assistive Technology and Design for All approach will need to coexist and cooperate in the short/medium term to grant as much as possible the inclusion of people with activity limitation.

The conceptual scheme and the steps leading to AmI deployment is assumed the following. The main Design Approach is Design for All, whose definition is presently being refined in connection to its use in the ICT environment. The same is true for the AmI concepts that are presently under discussion. In the near future, ICT will continue to develop with a Design for All approach, therefore producing more accessible mainstream technology. This will cause not only the emergence of intelligent objects but also their inclusion into AmI-like environments, i.e. environments that incorporate partially and in interconnected islands AmI concepts. AmI will materialise when the individual AmI-like islands will merge and when enough intelligence will be available to guarantee functionality and security of the infrastructure and the corresponding services throughout the entire society.

According to this scheme, after some general definitions in Chapter 1, Chapter 2 is devoted to a short summary of the features of the AmI environment and to the definition of the Design for All approach.

Chapter 3 deals with a description of the present situation, both from the perspective of ICT and AT. Furthermore, evidence is presented of the fact that DfA in ICT is not only an interesting conceptual construction and politically correct strategy, but that technical approaches exist that can actually make it real.

The aim of Chapter 4 is to argue that the transition toward AmI is undergoing in an incremental way, through the development of AmI-like environments, and to show that the main conceptual change is the use of the concept of integrated support. So far, Assistive Technology has supported the augmentation of the capabilities of the individuals and the adaptation of single artefacts for accessibility. The new approach is based on the assumption that the artefacts in the environment are interconnected and integrated in an "intelligent" control system, in order to support people with services and applications that offer useful functionalities. Therefore, the main emphasis is not on technology itself and its adaptation, but on useful functionalities the environments could or should offer irrespective of their technical implementation. Services in the environment will reduce the level of capacity needed to carry out the required activities.

Finally Chapter 5 takes us to the far future as described in the ISTAG (Information Society Technology Advisory Group) scenarios, where a complete implementation of the AmI environment is assumed. The possible impact on some groups of people with activity limitations is briefly analysed

[1] http://ec.europa.eu/information_society/events/ict_riga_2006/doc/declaration_riga.pdf

with suggestions of possible new opportunities and possible problems. The main conceptual change is that e-accessibility has dealt with tasks to be carried out to use equipment and services, while the AmI environment is dealing with goals of users to be automatically identified and proactively facilitated.

List of contributors

- S. Aalykke (DC)
- B. Dalgård Johansen (DC)
- C. Buehler (FTB)
- I. Klironomos (FORTH)
- M. Antona (FORTH)
- D. Kervina (UNI-LJ-SI)
- M. Pustišek (UNI-LJ-SI)
- P. Tahkokallio (STAKES)
- C. Tjader (SHI)

Table of Contents

1. Introduction

1.1. What is Deliverable D2.1 about?

One of the objectives of the DfA@eInclusion project is to identify and analyse possible opportunities as well as problems for different user groups in relation to the evolution toward an Information Society for all, to define likely exploitation of opportunities and possible solutions to the problems based on the Design for All (DFA) approach, and to make information available in a structured way by developing suitable dissemination material.

Therefore, as shown in Figure 1.1, the project will collect, in a structured form, knowledge about technology, standardisation and guidelines, policy and legislation, evaluation, and market, in order to concur to the diffusion of new concepts related to the evolving situation to the multidisciplinary community that is working in eInclusion (professionals, research, industry), to interact with the standardisation organisations (including the de facto standardisation) and to interact with policy makers. The collected knowledge will be the basis for documents meant to disseminate it at different levels.

Target audiences are:

a) Education sector (teachers, students, primary Master level);

b) Policy makers: EU and national;

c) Industry: executive management, research and development, marketing, communication;

d) Research Institutions

e) Standardisation bodies;

f) The EDeAN community.

The main objective is that at the end of the project activities it will be possible for professionals to have information about the present situation and possible developments in the short and long term, for universities to have materials for basic education in the field at the master level, for industry to have guidelines for training courses, as well as recommendations about the use of standards and guidelines for DfA, and for research organisations and funding bodies to have suggestions about needed future activities. The chosen approach is to produce a structured collation of information (production of state of the art reports/overviews) about the present situation and the possible impact of technological development (e.g. Ambient Intelligence (AmI) developments), standardisation, policy, benchmarking, foreseeable developments in the near future and possible fundamental changes in the medium/long term.

Indeed, our society is presently undergoing fast and important changes due to many concurring factors, one of which is the accelerating technological development. In particular, the fusion of telecommunications, information technology and media (ICT) industry, mainly due to the digitalisation of all media and the low cost of computers and computer based equipment, is blurring, from the user perspective, the border between access to information, interpersonal communication and environmental control in all living contexts and is leading to a reorganisation of the society toward an information society. This has also an impact on the situation of people with activity limitations[2] and on their ability to be included in the society.

[2] According to the recent World Health Organization (WHO) documents the locution "people with activity limitations" will usually be used in references to people who have problems in carrying out activities necessary for social inclusion, due to impairments and/or contextual factors.

The roles of the citizens in the emerging information society are being redefined and many activities (education, work, study, entertainment, etc.) are supposed to be mediated by technology. As is the case with all changes this may have contradictory effects on people. Therefore, one of the purposes of the present deliverable is to discuss the possible impact of the ongoing and foreseen technological developments on people with different activity limitations, starting from the present situation and considering short time developments and medium-long term scenarios of possible evolution, as a transition toward an information society based on the Ambient Intelligence paradigm.

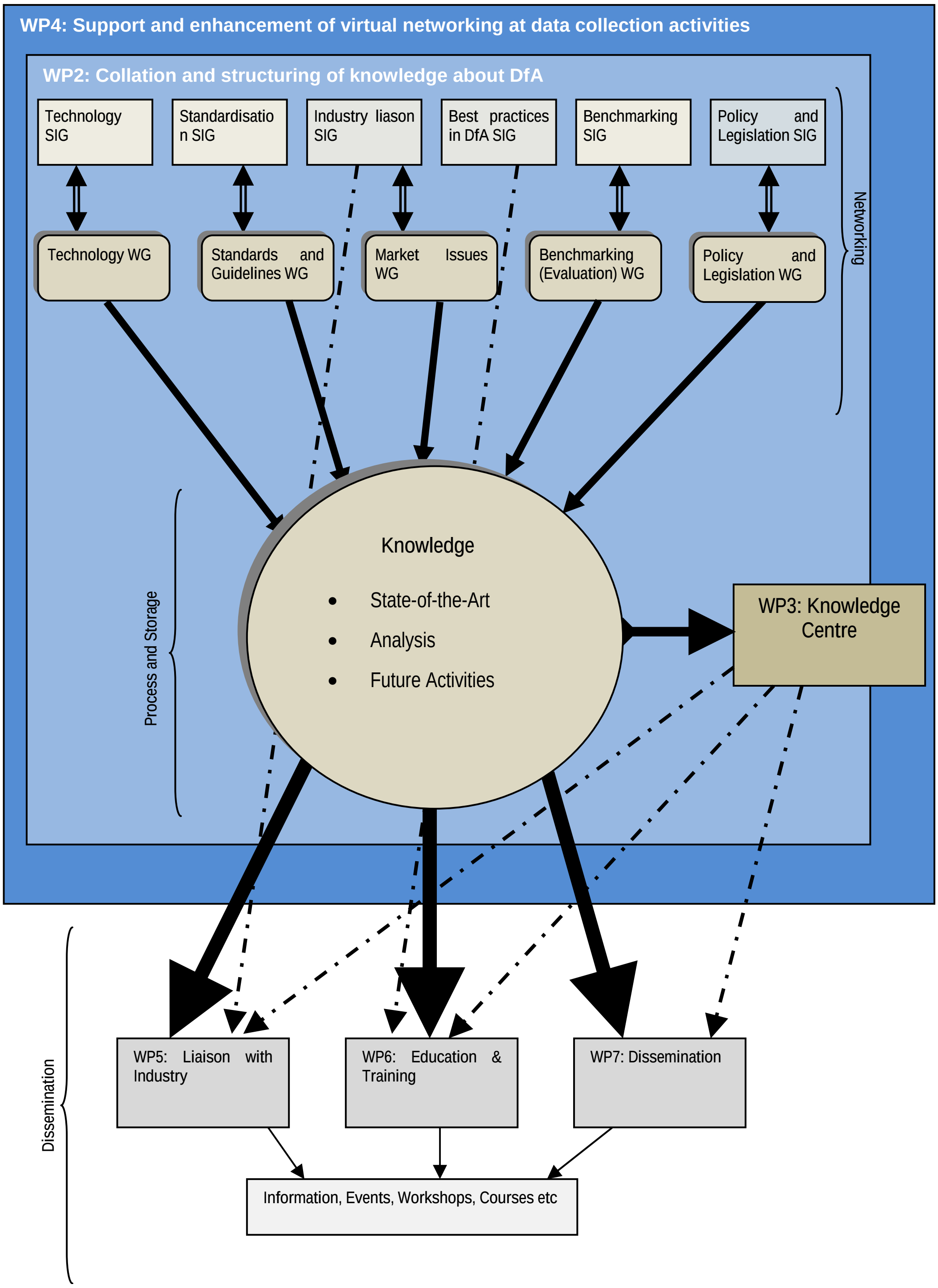


Figure 1.1: DfA@eInclusion: Overview of structure and interrelations.

The changes due to the transition toward an information society are so important that they are also causing a revision of the traditional way of using technology for favouring the social inclusion of people with activity limitations. So far, the Assistive Technology approach has been based on the adaptation of new technology (e.g. by changing the interface) in order to allow accessibility to equipment and services and on the use of the new technology to grant people with activity limitations abilities not yet possible (e.g. people with visual limitations writing and controlling what they have written). Presently, a new approach is advocated at a political level too, the "Design for All" or "Universal Design"[3] approach, according to which all systems, services and applications in the information society are designed in order to accommodate the needs, requirements and preferences, as far as possible, of the largest number of potential users. Therefore, a second task of the present deliverable is to give a "working" definition of the design for all approach and to show its main characteristics and technical feasibility.

1.2. How to use deliverable 2.1

The present document deals with technology and is based on the main assumption that there is a lot of information around about the possible impact of technological developments on the inclusion opportunities of all citizens, but this is not available in a form that can be tackled by a multidisciplinary group, i.e. it has not yet been formalised in knowledge and organised in a suitable form. Therefore, the first step towards the objectives stated above is to collect information in a form and at a level where interdisciplinary discussions can fruitfully take place, and, as a subsequent step, the cooperation between different disciplines can produce knowledge leading to breakthroughs able to improve over the apparent standstill in technical work on e-accessibility (including Assistive Technology). The document will summarize the present situation (mainly based on the use of Assistive Technology), showing, if they exist, limitations of the approach and possible improvements. Then the impact of ongoing technological development on improving the situation or in creating additional difficulties will be examined (with particular reference to Ambient Intelligence). Finally the long terms development towards the Information Society will be considered, pointing out, hopefully, new interesting possibilities or possible additional problems.

The structuring and presentation of the material is based on the following conceptual scheme. First, the definition of eInclusion as published in the Riga ministerial declaration is assumed:

"e-Inclusion" means both inclusive ICT and the use of ICT to achieve wider inclusion objectives. It focuses on participation of all individuals and communities in all aspects of the information society. e-Inclusion policy, therefore, aims at reducing gaps in ICT usage and promoting the use of ICT to overcome exclusion, and improve economic performance, employment opportunities, quality of life, social participation and cohesion. (Pt. 4 Ministerial Declaration Approved Unanimously on 11 June 2006, Riga)

This implies that all citizens have the right to be granted availability of all information and communication facilities in the Information Society and, when necessary and possible, to be supported by ICT for achieving their goals in all environments. The terms "Universal Access and Universal Accessibility" are used in the document as an indication of this right. eInclusion can be partially obtained by making system and services accessible to all citizens, but this is not enough. For example, when people are supported by ICT functionalities for independent living at home, particularly if they are cognitively impaired, this requires more than accessibility to systems and services. The environment must be able to support them with specific functionalities.

[3] As common in the ICT environment, "design for all" and "universal design" are used as synonyms in this document.

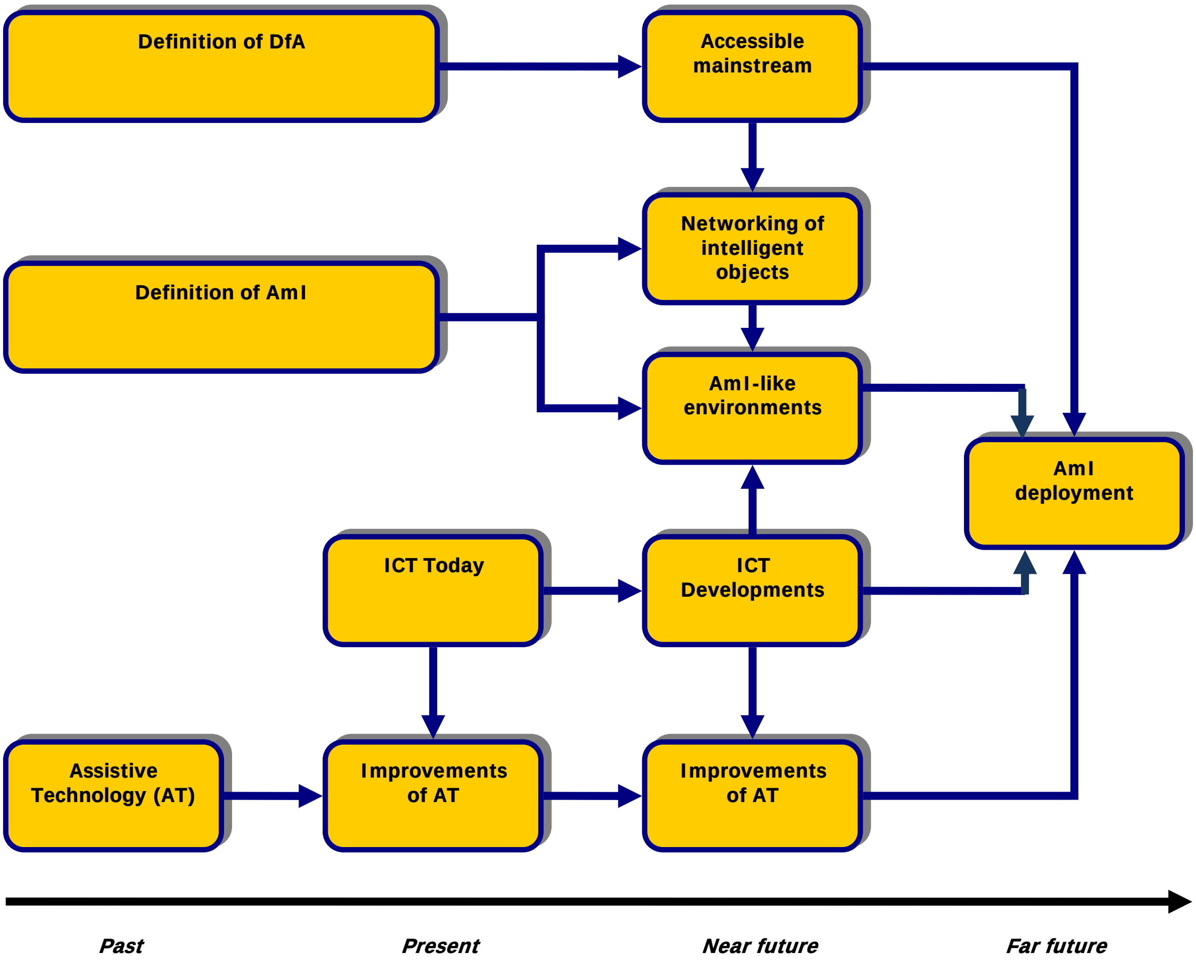


Figure 1.2: AmI deployment timeline.

Secondly, inclusion problems have been solved with adaptations and the use of Assistive Technology (AT) products has been a technical approach to obtain adaptations. Presently, there is a shift toward the "Design for All" approach, based on the conceptual principle that all users must be taken into account in the design of new products and on suitable technical approach(es) that can produce *designed for all* products.

Finally, it is assumed, according to all relevant Commission documents, that the European society is migrating toward an information society, described by the AmI paradigm (Ducatel et al.,2001), and that the approach to make it accessible and to use its features to support inclusion of people with activity limitations is the "Design for All" approach. However, it is additionally assumed that there will be a (long) transition to a complete AmI implementation and that the Assistive Technology and Design for All approach will need to coexist and cooperate to grant as much as possible the inclusion of people with activity limitation.

In Figure 1.2 the conceptual scheme and the steps leading to the AmI deployment are sketched, with reference to people with activity limitations, i.e. to Assistive Technology. As already mentioned, the design approach is Design for All, whose definition is presently being refined in connection to its use in the ICT environment. The same is true for the AmI concepts that are under discussion, due to the present development of ICT leading to future important changes in society (Information society) and offering the potential of improvements in Assistive Technology as well. In the near future, ICT will continue to develop with a Design for All approach, therefore producing more and more accessible mainstream technology. This will cause not only the emergence of intelligent objects and their inclusion into AmI-like environments, i.e. environments that incorporate partially and in interconnected islands AmI concepts. AmI will materialise when the individual AmI-like islands will merge and when enough intelligence will be available to guarantee functionality and security of the infrastructure and the corresponding services throughout the entire society.

According to this scheme, Chapter 2 of the deliverable is devoted to a short summary of the main features of the AmI environment and to a contextual definition of the Design for All approach, in connection with the traditional Assistive Technology approach.

Chapter 3 deals with a description of the present situation, both from the perspective of Information and Communication Technology (ICT) and Assistive Technology (AT). The main assumption is that Assistive Technology is not innovative enough to take advantage of the new opportunities offered by technology. Preliminary suggestions about how present technological developments could be exploited to improve the capabilities of Assistive Technology products are offered, as an input to next year deliverable dealing with the necessary research activities for improving the inclusion level of people with activity limitations. Furthermore, evidence will be presented of the fact that design for all in ICT is not only an interesting conceptual construction and politically correct strategy, but that technical approaches exist that can really make it real (Emiliani & Stephanidis, 2005). This will be shown through the description of the results of some European projects, which in the time span of about 15 years were able to show the possible transition from a purely reactive adaptation approach to a proactive Design for All approach (Stephanidis & Emiliani, 1999).

The aim of Chapter 4 is to argue that the transition toward AmI is undergoing in an incremental way and that technological developments, already available at least as laboratory prototypes, can improve the inclusion of people with activity limitations through a cooperation of AT with the new emerging designed for all AmI-like environments. The use of AmI like concepts in the development of living environment is shortly outlined. Then some new technological developments are described together with their possible impact on improving Assistive Technology and its integration in AmI environments for supporting people. The main aim is to show that the main conceptual change is the concept of integrated support. So far, Assistive Technology has supported the augmentation of the capabilities of the individuals to cope with the problems of access to information and interpersonal communication and to adapt single artefacts for accessibility. Now, the new conceptual approach is based on the assumption that the artefacts in the environment are interconnected and integrated in an “intelligent” control system, which is able to support the cooperation of the available artefacts and services[4] built on them for favouring inclusion. The change of paradigm is from equipment that is accessible or support people to services and applications that offer useful functionalities to user. Therefore, the main emphasis is not on technology itself, but on useful functionalities the environments could or should offer irrespective of the real technical implementation. This reflects the appreciation of the fact that, according to new WHO approach, difficulties in carrying out activities are not only due to limitations of people but also to contextual factors. As a consequence, these difficulties can be alleviated not only augmenting the capacities of people but also making available in the environment functionalities (services), which reduce the level of capacity needed to carry out the required activities. It must be observed here that one of the main characteristics of the emerging services and applications is that they favour cooperation through the network. The new ICT model is not a person interacting with a computer to access information or communicate with another person, but the emphasis is on groups of interacting users, who cooperatively access information and carry out

[4] **Definition of services and applications** – In this deliverable any functionality made available to carry out activities of importance to access to information and interpersonal communication is referred to as a service. The (integrated) use of services to fulfil practical goals is referred to as an application. For example, telephony is a service allowing interpersonal communication by voice. The use of telephony to transmit data of medical relevance is a health care application.

activities of common interest. This means that people can remotely concur to increase intelligence in the environment and to provide some of the necessary functionalities.

Finally Chapter 5 takes us to the far future as described in the ISTAG scenarios, where a complete implementation of the AmI environment is assumed. The possible impact on some groups with activity limitations is briefly analysed with suggestions of possible new opportunities and possible problems. The main conceptual change is that the e-accessibility sector has dealt with the accessibility to systems (e.g. computers and terminals) and tasks to be carried out, while the AmI environment is dealing with goals of users to be automatically identified and proactively facilitated. This is the main purpose of the intelligence in AmI.

It is clear that, dealing with a set of technologies very complex and rapidly changing, the document cannot pretend to be complete. Furthermore, it runs the risk of being obsolete before its delivery. Therefore, the document will try to characterise technology at the level of functionalities and to point out what is of interest for the analysis of its impact on people with activity limitations. For example, in the case of mobile telephony what is important is the bandwidth (that is the amount of digital information that can be conveyed to the user in addition to the normal voice channel), the coverage of the operators, the additional services available, not the algorithms for coding the voice channel.

Therefore, instead of covering all technologies and possible applications, the main aim of the deliverable is to show a methodology to consider the problems of inclusion that is based on the inclusion of different possible interventions, ranging from the use of conventional Assistive Technology to the identification of Design of All approach for the development of AmI environments able to include all people irrespective of their individual capabilities. This methodology starts from the fact that the focus of any (technological) reorganisation of the society is the citizen, who must be given the possibility of living comfortably and have access to all the aspects of the society itself. This means that it is necessary to take advantage of and integrate all the human and technical resources in order to favour the inclusion of all citizens in the society irrespective of their personal or contextual abilities. An evolution must be made possible from methodologies of inclusion mainly based on adaptation with Assistive Technology products toward mainstreaming of accessibility through design for all approaches. Moreover, the model of an individual person interacting with a system (computer and/or terminal) must migrate toward the concept of individuals immersed in an environment populated by "intelligent" interconnected objects that is supposed to become itself "intelligent" in order to proactively offer functionalities (services).[5]

Finally, it will be shown, through some examples that are due to be completed next year with an analysis of the necessary research activities in eInclusion, that even the available technology is not used as far as possible in this field and that technology that could have an important impact in Assistive Technology and in the emerging AmI-like environments is supposed to reach the market in the near future.

Hopefully, people reading this document will be more aware of the components of the analyses leading to a correct use of technology in promoting inclusion in the information society. If working in connection with people, they should be more able to use technical knowledge in their activities and if working with technology, they should acquire additional knowledge on user needs.

[5] The adjective "intelligent" is used here among inverted commas because one of the main ideas expressed in the deliverable is that there is not yet enough intelligence in the objects and in the environments, for taking full advantage of the potentialities of the AmI approach.

2. Toward the Information Society

2.1. Introduction

Chapter 2 is devoted to the introduction of two aspects that are fundamental for the discussion of the inclusion of citizens in the information society, with particular reference to citizens with activity limitations.

The first is the way the information society will materialise. In this deliverable, the model presented in the ISTAG documents (Ducatel et al., 2001), which foresee the future society as an ambient intelligent environment, is assumed. The main characteristics, at the functional level, of AmI are presented as a support to the discussion of their impact on the inclusion of all citizens.

The second is the Design for All approach. A definition with reference to the ICT environment, which the deliverable is referring to, is presented, pointing out the main differences with the definition used in the architecture and design environments.

Moreover, it is argued that the Design for All approach is not only an interesting conceptual model, but it is also feasible from a technological perspective. Therefore, a technical approach to its implementation is briefly outlined too, based on the concept of adaptivity and adaptability of systems, services and applications.

2.2. Ambient Intelligence

It is commonly accepted that society is undergoing a fundamental transition, from the present industrial society towards an information society. Among the possible embodiments of the emerging information society, an interesting and widely discussed potential instantiation is the Ambient Intelligence (AmI) paradigm (in Europe see, for example, the ISTAG documents). The information society is not seen as being characterised by an increased diffusion and use of present-day computers and telecommunication terminals, but as the emergence of an environment in which people are surrounded by fixed and mobile intelligent objects, interconnected through fixed and mobile networks, and capable of recognising and responding to the presence of different individuals. The interaction with the objects and with the intelligence in the environment will allow access to information, interpersonal communication and environmental control. This vision is present not only in the European documents, but also in documents of different countries, for example, Australia (Australian Communications Authority, 2005), Japan (Soumo, 2004, 2005, 2006, 2007) and USA (NIST, 2008), produced both by industries, as for example, Rand (Antòn et al, 2001), Xerox (Xerox Innovation, 2005), Microsoft, IBM, Philips (Aarts, 2004), Siemens (Siemens AG, 2004), Fujitsu (Fujitsu, 2005) and universities, for example, MIT has an Ambient Intelligence Laboratory[6] and many research projects around it. Apparently, this idea is popular also in the research environment.

The AmI environment will be populated by a multitude of hand-held and wearable "micro-devices" and computational power and interaction peripherals (e.g., embedded screens and speakers, ambient displays) will be distributed in the environment (Figure 2.1). Devices will range from "personal" (e.g., wrist-watches, bracelets, personal mobile displays and notification systems, health monitors embedded in clothing), carrying individual and possibly private information, to "public" in the surrounding environment (e.g., wall-mounted displays) (Streitz, 2005).

[6] http://www.media.mit.edu/research/955

Figure 2.1: Innovative office environments focused (picture taken from Streitz, 2005).

As technology ‘disappears’ from humans both physically and mentally, devices will be no longer perceived as computers, but rather as augmented elements of the physical environment. Personal devices will be equipped with facilities for multimodal interaction and alternative input/output (e.g., voice recognition and synthesis, pen-based pointing devices, vibration alerting, touch screens, input prediction, etc), or with accessories that facilitate alternative ways of use (e.g., hands-free kits), thus addressing a wider range of user and context requirements than the traditional desktop computer. A variety of new products and services will be made possible by the emerging technological environment, including home networking and automation, mobile health management, interpersonal communication, and personalised information services. These applications will be characterised by increasing ubiquity, nomadism and personalisation, and are likely to pervade all daily human activities. They will have the potential to enhance security in the physical environment, save time, augment human memory and support people in daily routines and simple activities, as well as in complex tasks.

This development is potentially very promising for users. According to European development scenarios, from a socio-economic perspective Ambient Intelligence is supposed, according to ISTAG:

- to facilitate human contacts;
- to be oriented towards community and cultural enhancement;
- to help build knowledge and skills for work, better quality of work, citizenship and consumer choice;
- to inspire trust and confidence;
- to be consistent with long-term sustainability - personal, societal and environmental - and with life-long learning;
- to be controllable by ordinary people.

Moreover, from a human-computer interaction perspective, interaction with the intelligent environment will have to be redefined. Namely, the Ambient Intelligence environment must be unobtrusive (i.e. many distributed devices are embedded in the environment, and do not intrude into our consciousness unless we need them), personalized (i.e. it can recognize the user, and its behaviour can be tailored to the user's needs), adaptive (i.e. its behaviour can change in response to a person's actions and environment), and anticipatory (i.e. it anticipates a person's desires and environment as much as possible without the need for mediation). Therefore, the emphasis is put on greater user-friendliness, more efficient support of services, user-empowerment, and support for human interaction. Interaction is intended as taking place through "natural" interfaces.

In order to have an idea of the type of technology, interactions and services available in the information society, let us now summarize what are their main characteristics as described in the ISTAG scenarios. First of all the hardware is supposed to be *very unobtrusive*. Miniaturisation is assumed to produce the necessary developments in micro and optical electronics, smart materials and nanotechnologies, leading to:

- self-generating power and micro-power usage;
- breakthroughs in input/output systems including new displays, smart surfaces, paints and films that have smart properties;
- sensors and actuators integrated with interface systems in order to respond to user senses, posture and environment.

Many technologies are conceived as hand-held or wearable, taking advantage of the fact that intelligence can be embedded in the environment in order to support the individual personal system. This means being light-weight, but also availability. It is taken for granted that people can have with them everything necessary for performing even complex tasks. For example the only communication item (sufficient e.g. for carrying out navigation, environmental control, and communicating with other people) foreseen in the ISTAG scenarios is a Personal Communicator (P-Com). Its characteristics are not precisely defined. It does not have a specifically defined interface, but is a disembodied functionality supported by the Ambient Intelligence with different interfaces. It is adaptive, and learns from user's interactions with the environment. It offers communication, processing and decision-making functions. Finally, it must not necessarily be a highly sophisticated piece of equipment, whose performances are limited by size, weight, and power. The intelligence necessary to support the transduction of information necessary to address the different modalities and to support the user can be in the environment and in the network. In principle, the only limiting factor can be bandwidth.

Then a *seamless mobile/fixed web-based communications infrastructure* is supposed to be available. Complex heterogeneous networks need to function and to communicate in a seamless and interoperable way. This implies a complete integration of mobile and fixed networks, including ultra fast optical processing. These networks will have to be seamless and dynamically reconfigurable.

Dynamic and massively distributed device networks will be in place. The AmI landscape is a world in which there are almost uncountable interoperating devices. Some will be wired, some wireless, many will be mobile, many more will be fixed. The requirement will be that the networks should be configurable on an *ad hoc* basis according to a specific, perhaps short-lived, task, with variable actors and components.

Human interfaces will have to become *natural*. A central challenge of AmI is to create systems that are intuitive in use. This will need *Artificial Intelligence* techniques, especially dialogue-based and goal orientated negotiation systems, as the basis for intelligent agents and intuitive human to machine interaction, which is supposed to be multimodal, multi-user, multilingual, multi-channel and multipurpose. It should also be adaptive to user requirements providing context sensitive interfaces and information filtering and presentation.

Finally, the AmI-world must be *safe, dependable and secure*, considering all physical and psychological threats that the technologies might imply and giving important emphasis on the requirement for robust and dependable software systems components.

2.3. Assistive Technology and Design for All

2.3.1. From Accessibility to Universal Access

The developments toward an Information Society are expected to alter human interaction, individual behaviour and collective consciousness, as well as to have major economic and social effects (Danger et al., 1996). As with all major technological changes, this can have disadvantages and advantages. New opportunities are offered by the technological developments, the reduced need of mobility, due to the emergence of networked collaborative activities, and the increased possibility of network mediated interpersonal communications. However, difficulties may arise in accessing multimedia services and applications when users do not have sufficient motor or sensory abilities. The complexity of control of equipment, services and applications, and the risk of information overload, may create additional problems.

The above mentioned problems are particularly relevant for people with disabilities, who have been traditionally underserved by technological evolution. Disabled and elderly people currently make up about the 20% of the market in the European Union, and this proportion will grow with the ageing of the population (Figure 2.2) to an estimated 25% by the year 2030 (Vanderheiden, 1990; Gill, 1996).

Not only there is a moral and legal obligation to include this part of the population in the emerging Information Society, but there is also a growing awareness in the industry that disabled and elderly people can no longer be considered as insignificant in market terms. Instead, they represent a growing market to which new products can be provided. However, due to the foreseen increase of citizens who will need to interact with the emerging technological environment, accessibility can no longer be considered as a specific problem of people with impairments, but of the society at large, if suitable actions are not undertaken.

Therefore, in this document it is argued that in this dynamically evolving technological environment, accessibility and usability of such complex systems by users with different characteristics and requirements cannot be addressed through ad hoc Assistive Technology solutions introduced after the main building components of the new environment are in place. Instead, there is a need for more proactive approaches, based on a ‘‘Design for All’’ philosophy, (Emiliani and Stephanidis, 2005) along with the requirement of redefining the role and scope of assistive technologies in the new environment. In such a context, the concepts of Universal Access and Design for All acquire critical importance in facilitating the incorporation of accessibility in the new technological environment through generic solutions.

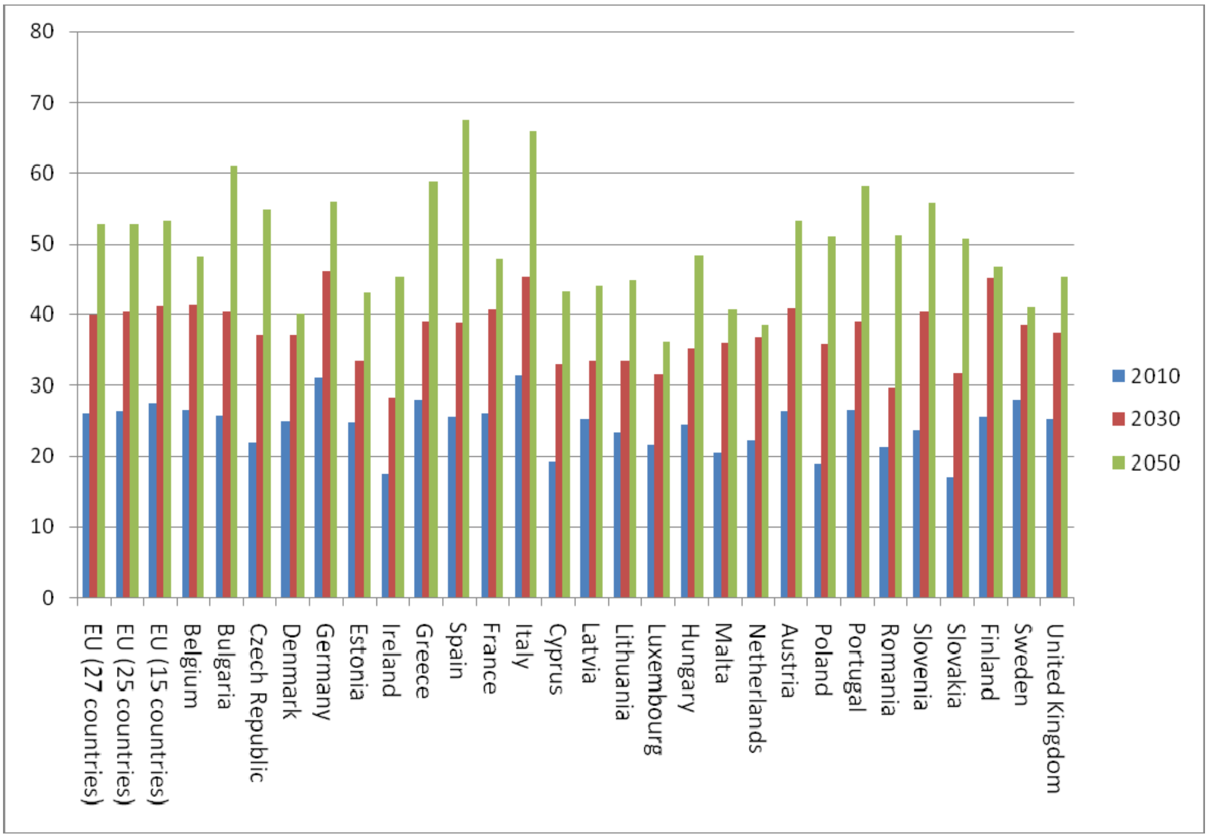


Figure 2.2: Projected Forecasts of the percentage of EU citizens aged 65 and over, expressed as a percentage of the projected number of persons aged between 15 and 64 in years 2010, 2030 and 2050. Data source: Eurostat, Projected old-age dependency ratio : http://epp.eurostat.ec.europa.eu/portal/page?_pageid=1996,45323734&_dad=portal&_schema=PORTAL&screen=welcomeref&open=/&product=REF_SD_DE&root=REF_SD_DE&depth=3.

It is important here to introduce some definition of terms and discuss about the different concepts that will be used in the following presentation. Universal Access and Universal Accessibility are used in the document as an indication of the right of all citizens to be granted availability of all information and communication facilities in the Information Society. This can be partially obtained by making them accessible to all citizens. Therefore access and accessibility are used as an approach toward eInclusion. However this is not enough. For example, when people are supported by ICT functionalities for independent living at home, particularly if they are cognitively impaired, this requires more than accessibility to systems and services. The environment must be able to support them with specific functionalities.

Traditionally, accessibility problems have been solved with adaptations and the use of Assistive Technology products has been a technical approach to obtain adaptations. Presently, there is a shift toward the "Design for All" approach. The term Design for All is used, sometimes causing confusion, as an indication of the conceptual principle that all users must be taken into account in the design of new products and of the technical approach(es) that can produce *designed for all* products. Apparently, there is a conceptual confusion between the concepts of Universal Access, i.e. a right of all citizens, and Design for All (Universal Design), i.e. a possible approach to grant this right. What is considered important, particularly in the field of disability, is granting people Universal Access. This is clearly right, but the claim that, therefore, everything that aims to give accessibility to all is Design for All is conceptually misleading. Design for All is a well defined approach, particularly promising due to the developments of the Information Society, which must coexist at least in the short medium terms with Assistive Technology to serve all potential users of ICT systems, services, and applications.

Universal Access implies the accessibility and usability of information and telecommunications technologies by anyone at any place and at any time and their inclusion in any living context. It aims to enable equitable access and active participation of potentially all people in existing and emerging computer-mediated human activities, by developing universally accessible and usable products and services and suitable support functionalities in the environment. These products and services must be capable of accommodating individual user requirements in different contexts of use, independent of location, target machine, or runtime environment. Therefore the approach aiming to grant the use of equipment or services is generalized, seeking to give access to the Information Society as such. Citizens are supposed to live in environments populated with intelligent objects, where the tasks to be performed and the way of performing them are completely redefined, involving a combination of activities of access to information, interpersonal communication, and environmental control. Citizens must be given the possibility of carrying them out easily and pleasantly.

This final observation is very important in order to understand that accessibility is not enough, but the concept of Universal Access must be introduced, and that adaptations are not any more a real option for satisfying the eInclusion requirements. Design for All has been mainly introduced in human computer interaction on the basis of serving a variety of users, which means addressing diversity of users. The line of reasoning is that since users are different and they have different accessibility and usability requirements, it is necessary to take all of them into account in a user-centred design procedure. But, the emerging environment is much more complex and diversity must be considered from other perspectives. First of all the interaction is not any more with computers and terminals, but with the environment and objects in it. Therefore, it will be necessary to consider a variety of interaction paradigms, metaphors, media and modalities. Then, users/citizens will not have to cope with tasks determined by the used application, but with goals to reach in everyday life, which will be different in different environments and for different users. Additionally, goals may be complex not only due to the foreseen merging of functions connected to access to information, interpersonal communication, and environmental control, but also because they may involve communities of users. Finally the same goal must be reached in many different contexts of use. This gives an idea of the complexity of the involved problems, the limitation of the classical accessibility concepts, and the need for innovative approaches.

This has also an impact on the technological approach to the problem of accessibility. Universal Access needs a conscious and systematic effort to proactively apply principles, methods and tools of Design for All, in order to develop Information Society technologies and environments, which are available to all citizens, including very young and the elderly people, and people with different types of activity limitations, thus avoiding the need for a posteriori adaptations or specialized design. The requirement for Universal Access stems from the growing impact of the fusion of the emerging technologies, and from the different dimensions of diversity, which are intrinsic to the Information Society. These dimensions become evident when considering the broad range of user characteristics, the changing nature of human activities, the variety of contexts of use, the increasing availability and diversification of information and knowledge sources and services, the proliferation of technological platforms, etc.

2.3.2. The reactive (adaptation) approaches

2.3.2.1. Historical perspective

When the interest in the use of information technology and telecommunications for people with activity limitations started, the situation was relatively simple: the main service for interpersonal communication was the telephone, and information was distributed by means of radio and television. Computers were mainly stand-alone units (mainframes) used in closed and specialised communities (e.g. those of scientists and businessmen).

In principle, the telephone was a fundamental problem only for profoundly deaf people. For all other groups of people with disabilities, solutions were within the reach of relatively simple technological adaptations. The technology used for implementing the telephone lent itself to the possibility of capturing the signal (electromagnetic induction) and making it available for amplification for deaf people. Even the problems of profoundly deaf people were facilitated by the telephone system itself, when it was discovered that the telephone line could be used to transmit digital data (characters) with suitable interfaces (modems). Radio was an important medium for the diffusion of information. In principle, radio can represent a problem for deaf people. But since amplification is inherent in a radio system, problems occur again therefore only for profoundly deaf people. Television was the first example of a service that used the combination of the visual and acoustic modalities, not redundantly, but for conveying different types of information. Being more complex, television could create more difficulties for people with disabilities, but it had inherent capabilities for overcoming some of the problems. It is evident that television can create problems to blind, visually-disabled and deaf people. On the other hand, the fact that additional information can be transmitted by exploiting the available bandwidth enables support for people with activity limitations to be added to the standard service. Therefore, programmes can be subtitled for deaf people, and scenes without dialogue can be described verbally for blind people. In addition, text services can be set up (e.g. televideo, teletext), thus solving some of the problems related to the accessing of information by profoundly deaf people.

Television is a simple example of a general situation. An increase in the complexity of a system or service increases the number and extent of problems that such a system or service can create for people who have reduced abilities with respect to the majority of the population. At the same time, technical complexity often implies additional features in order to recover from this unfortunate situation, as well as the possibility of using the same technology in an innovative way to solve problems that have not yet been addressed.

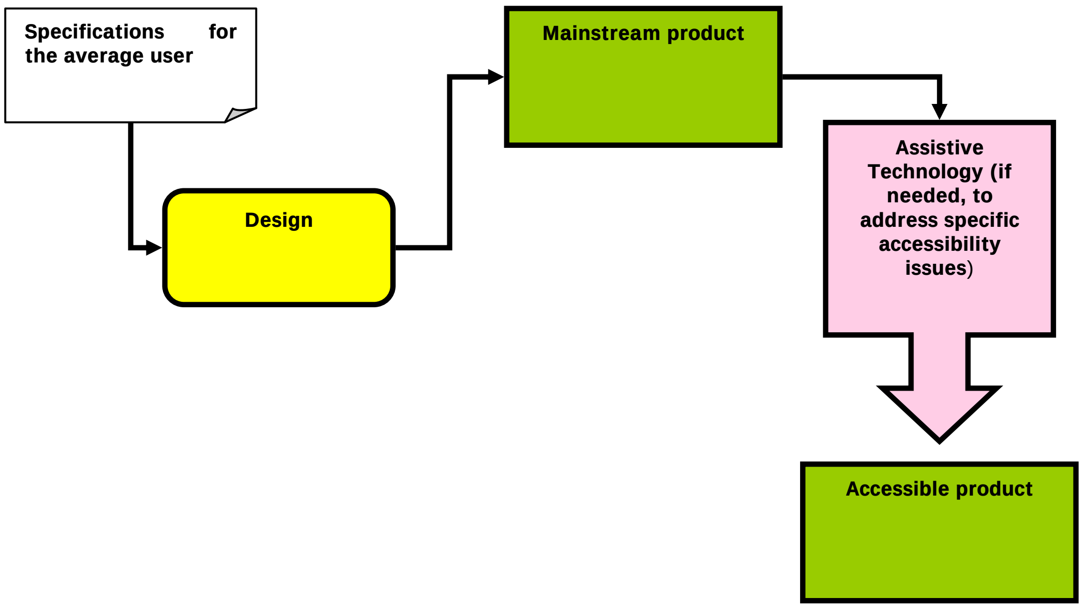


Figure 2.3: The Assistive Technology approach.

The situation started to change, thanks to the development of computers and technology able to increase the bandwidth of communications channels, which ultimately contributed to creating a completely new environment for communication and access to information, as will be briefly described in the following. From the perspective of the user, the first important innovation was brought about by the introduction of personal computers. Personal computers were immediately seen as a new and very important possibility for supporting people with disabilities in communication and providing access to information. Unfortunately, they were not directly accessible to some user groups, such as blind people and people with motor impairments of the upper limbs. However, the possibility of encoding information, instead of printing it on paper, was immediately perceived as being of paramount importance for people who cannot see. Therefore, personal computers had to be made available to them. Adaptations were investigated, and through the synergy of new transduction technologies (mainly synthetic speech) and specialised software (screen readers), capable of "stealing" information from the screen and making it available to appropriate peripheral equipment, coded information was made available to blind people (Mynatt & Weber, 1994). Blind people could also read information retrieved from remote databases, and write and communicate using electronic mail systems. Adaptations for motor-disabled people (special keyboards, mouse emulators) and for other categories of people with activity limitations were also made available. Therefore, the personal computer was made available using adaptations (Assistive Technology) approach depicted in Figure 2.3.

It can therefore be concluded that, when the interest in accessibility by people with activity limitations became more widespread, the worldwide technological scene was dominated by a set of established equipment and services. The situation required adaptations of existing systems, which slowly became available with long delays.

2.3.2.2. Limitations of the reactive (adaptation) approaches

The traditional approach to rendering applications and services accessible to people with disabilities is to adapt such products to the abilities and requirements of individual users. Typically, the results of adaptations involve the reconfiguration of the physical layer of interaction and, when necessary, the transduction of the visual interface manifestation to an alternative (e.g. auditory or tactile) modality.

Although this may be the only viable solution in certain cases, the reactive approach to accessibility (Vanderheiden, 1998) suffers from some serious shortcomings. One of the most important is that by the time a particular access problem has been addressed, technology has advanced to a point where the same or a similar problem re-occurs. The typical example that illustrates this state of affairs, is the case of blind people's access to computers. Each generation of technology (e.g., DOS environment, Windowing systems, and multimedia) caused a new wave of accessibility problems to blind users, addressed through dedicated techniques such as text translation to speech for the DOS environment, off-screen models and filtering for the Windowing systems.

In some cases, adaptations may not be possible at all, without loss of functionality. For example, in the early versions of windowing systems, it was impossible for the programmer to obtain access to certain window functions, such as window management. In subsequent versions, this shortcoming was addressed by the vendors of such products, allowing certain adaptations (e.g., scanning) on interaction objects on the screen. Finally, adaptations are programming-intensive and therefore are expensive and difficult to implement and maintain. Minor changes in product configuration, or the user interface, may result in substantial resources being invested to re-build the accessibility features. The situation is further complicated by the lack of tools to facilitate ease "edit-evaluate-modify" development cycles (Stephanidis et al., 1995). Moreover, reactive solutions typically provide limited and low-quality access. This is evident in the context of nonvisual interaction, where the need has been identified to provide nonvisual user interfaces that go beyond automatically generated adaptations of visual dialogs.

Traditionally, two main technical approaches to adaptation have been followed: product-level adaptation and environment-level adaptation. The former involves treating each application separately and taking all the necessary implementation steps to arrive at an alternative accessible version. In practical terms, product-level adaptation practically often implies redevelopment from scratch. Due to the high costs associated with this strategy, it is considered the least favourable option for providing alternative access. The alternative involves intervening at the level of the particular interactive application environment (e.g., Microsoft Windows™ or the X windowing system) in order to provide appropriate software and hardware technology to make that environment alternatively accessible. Environment-level adaptation extends the scope of accessibility to cover potentially all applications running under the same interactive environment, rather than a single application, and is therefore considered a superior strategy. In the past, the vast majority of approaches to environment level adaptation have focused on access to graphical environments by blind users. Through such efforts, it became apparent that any approach to environment-level adaptation should be based on well documented and operationally reliable software infrastructures, supporting effective and efficient extraction of dialog primitives during user-computer interaction. Such dynamically extracted dialog primitives are to be reproduced, at runtime, in alternative I/O forms, directly supporting user access. Examples of software infrastructures that satisfy these requirements are the Active Accessibility™ Technology from Microsoft Corporation[7], and the Java™ Accessibility Technology, from Sun Microsystems[8].

2.3.3. The proactive (Design for All) approaches

2.3.3.1. Need of proactive approaches

So far, the situation of people with activity limitations has been that they must wait for the technology, even if potentially very promising, to be adapted for their use. Traditionally, adaptation has been the magic word in the disability environment. The living environment, not only technology, has normally been designed for the "average" user and then adapted to the needs of people who are more or less far from "average". Architects then started to think that it might be possible to design public spaces and buildings accessible to everyone, even, for example, those who move about in a wheelchair. This approach (Design for All, or Universal Design) resulted in successful designs for landscapes, which were subsequently documented as guidelines for accessible built environments. It took several years before the approach was able to gather the political support needed for a real application, but the main principles had been developed. Moreover, it turned out that the approach was invaluable not only for people with activity limitations, but for the population at large. It is only a pity that too many buildings and public spaces are constructed at present, the designers of which do not take these basic principles into consideration.

More recently, in ICT as well, due to the above shortcomings of the reactive approach to accessibility, there have been proposals and claims for proactive strategies, resulting in generic solutions to the problem of accessibility. Proactive strategies entail a purposeful effort to build access features into a product, as early as possible (e.g., from its conception, to design and release). Such an approach aims to minimise the need for a posteriori adaptations and deliver products that can be tailored for use by the widest possible end-user population. In the context of Human Computer Interaction, such a proactive paradigm should address the fundamental issue of "Universal Access" not only to the user interface but also to services and applications (e.g. for access to information and interpersonal communication, namely of how it is possible to design systems that permit systematic and cost-effective approaches to accommodating all users (Stephanidis, 1995a; Mueller et al., 1997).

2.3.3.2. Definition of Design for All

There are many definitions of Design for All (or Universal Design, according to the USA locution). As a first definition let us consider the one that is available in the web site of the Trace Center, a research organisation devoted to make technologies accessible and usable: "The design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design[9]".

[7] See http://msdn2.microsoft.com/en-us/library/ms697707.aspx, last visited on 18 December 2008
[8] See http://java.sun.com/javase/technologies/accessibility/index.jsp, last visited on 18 December 2008
[9] See http://trace.wisc.edu/world/gen_ud.html, last visited on 18 December 2008

At the industrial level, Fujitsu has recently published an entire number of their journal completely devoted to Universal Design, defined as: "designing products, services, and environments so that as many people as possible can use them regardless of their age and physical characteristics (e.g., height, visual and hearing abilities, and arm mobility)".

Finally, in a research organization, Design for All in the Information Society has been defined (Stephanidis et al., 1998a) as the conscious and systematic effort to proactively apply principles, methods and tools, in order to develop Information Technology and Telecommunications (IT&T) products and services which are accessible and usable by all citizens, thus avoiding the need for a posteriori adaptations, or specialised design.

Figure 2.4 synthesizes the components of a proactive (Design for All) approach, emphasizing that it is not only necessary to have a user centred procedure for channelling user needs, requirements and preferences as part of the specifications for the design, but it is also necessary to develop technical approaches able to really addressing diversity (e.g. a technical approach based on adaptability and adaptivity). An optional Assistive Technology component is considered to emphasize the need of a transition from the present situation to the point when the Design for All approach will be completely deployed.

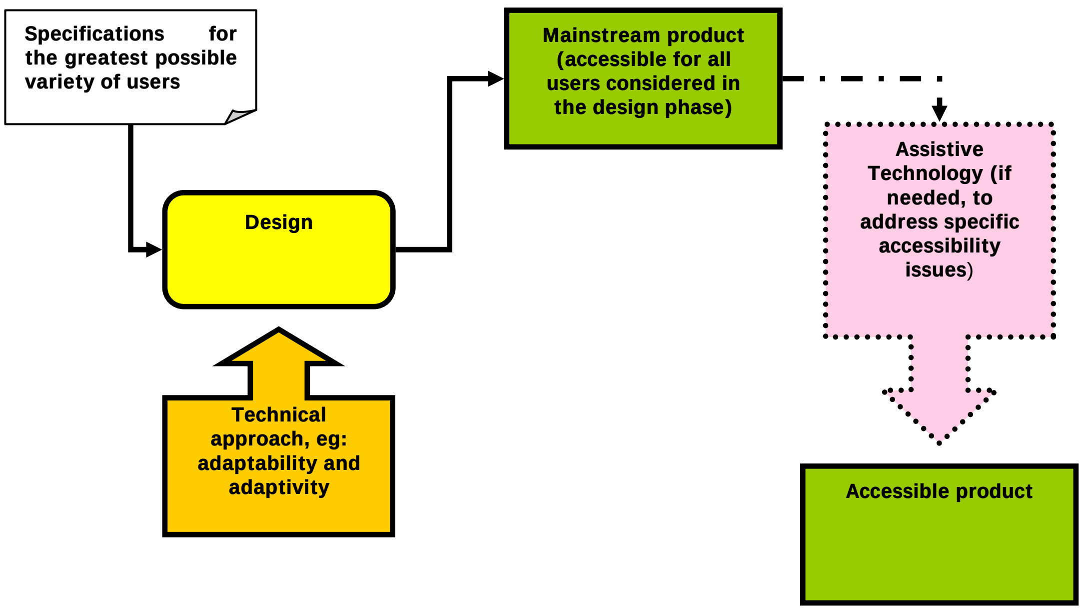


Figure 2.4: The Design for All approach.

The above definitions are conceptually based on the same principle, i.e. the recognition of the social role of the access to the information and telecommunication technologies, which leads to the need of design approaches based on the real needs, requirements and preferences of all the citizens in the Information Society, the respect of the individuals willing to participate in social life, and their right of using systems/services/applications. Furthermore, computer accessibility is gradually being introduced in the legislation of several countries. For example, in the United States, since 1998, Section 508[10] of the Rehabilitation Act 16 requires that ''any electronic information developed, procured, maintained, or used by the federal government be accessible to people with disabilities.'' In

[10] http://www.section508.gov/

Europe, the eEurope 2005[11] and the i2010[12] action plans and related resolutions of the European Council commit the member states and European institutions to design public sector Web sites and their content to be accessible, so that citizens with activity limitations can access information and take full advantage of the Information Society. The legal obligation to provide accessible interactive products and services may contribute to the adoption of systematic design approaches under a Design-for-All perspective.

The approach is also in line with the one at the basis of the preparation of the new WHO "International Classification of Functioning, Disability and Health (ICF)"[13], where a balance is sought between a purely medical and a purely social approach to the identifications of problems and opportunities for people in their social inclusion. When dealing with the problems of people who experience some degree of activity limitation or participation restrictions, "ICF uses the term *disability* to denote a multidimensional phenomenon resulting from the interaction between people and their physical and social environment". This is very important, because it allows grouping and analysis of limitations that are not only due to impairments. For example, people are not able to see because they are blind, or have fixation problems due to spastic cerebral palsy, or are in a place with insufficient illumination, or are driving and therefore cannot use their eyes for interacting with an information system. People may have impairments, activity limitations or participation restrictions that characterise their ability (capacity) to execute a task or an action (activity), but their performance is influenced by the current environment. The latter can increase the performance level over the capacity level (and therefore is considered a facilitator) or can reduce the performance below the capacity level (thus being considered as a barrier).

Here the emphasis on the fact that all people, irrespective of their capacity of executing activities, may perform differently according to the different contexts and that the environment must be designed to facilitate their performances.

2.3.3.3. Uptake of the Design for All approach

Even if there is, apparently, a convergence on the conceptual definition of Design for All, there is not enough interest and sometimes scepticism about it among people working in the social inclusion of people with disabilities, where the related concepts were firstly explored in ICT. This is essentially due to the fact that borrowing the general definition from architecture and industrial design, one is lead to think that the same technical approach to the implementation of the principle can be used, i.e. that Design for All in ICT can be obtained designing an artefact (e.g. a human computer interface) usable by all users. Therefore, there is an argument which raises the concern that ''many ideas that are supposed to be good for everybody aren't good for anybody'' (Lewis and Riemann, 1993). However, Design for All in the context of information technologies should not be conceived of as an effort to advance a single solution for everybody, but as a user-centred approach to providing products that can automatically address the possible range of human abilities, skills, requirements, and preferences. Consequently, the outcome of the design process is not intended to be a singular design, but a design space populated with appropriate alternatives, together with the rationale underlying each alternative, that is, the specific user and usage context characteristics for which each alternative has been designed.

If this is the case, then it is argued that this is clearly impossible or too difficult for being of practical interest. This is due to the fact that, even if it is true that existing knowledge may be considered sufficient to address the accessibility of physical spaces, this is not the case with information technologies, where Universal Design is still posing a major challenge. However, important advances

[11] http://ec.europa.eu/information_society/eeurope/2005/all_about/action_plan/index_en.htm
[12] http://ec.europa.eu/information_society/eeurope/i2010/index_en.htm
[13] http://www3.who.int/icf/icftemplate.cfm

are being made in the development of concepts and technologies that are considered necessary for producing viable Design for All approaches. Examples of implementation of the Design for All approach with present technologies in terms of systems and services adaptable to different abilities and adaptive in real time to the varying needs of people in changing contexts of use will be described in the following chapter.

Another common argument is that Design for All is too costly (in the short term) for the benefits it offers. Though the field lacks substantial data and comparative assessments as to the costs of designing for the broadest possible population, it has been argued (National Council on Disability, 2006) that (in the medium to long term) the cost of inaccessible systems is comparatively much higher and is likely to increase even more, given the current statistics classifying the demand for accessible products.

The origins of the concept of Universal Access in ICT are to be identified in approaches to accessibility mainly targeted towards providing access to computer-based applications by users with disabilities. Today, Universal Access encompasses a number of complementary approaches, which address different level of activities leading to the implementation of designed for all artefacts.

At the level of design specifications, for example, there are lines of work that aim to consolidate existing wisdom on accessibility, in the form of general guidelines or platform- or user-specific recommendations (e.g., for Graphical User Interfaces - GUIs or the Web). This approach consolidates the large body of knowledge regarding people with activity limitations and alternative Assistive Technology access in an attempt to formulate ergonomic design guidelines that cover a wide range of activity limitations. In recent years, there has also been a trend for major software vendors to provide accessibility guidance as part of their mainstream products and services. Moreover, with the advent of the World Wide Web, the issue of its accessibility recurred and was followed up by an effort undertaken in the context of the World Wide Web Consortium (W3C) to provide a collection of accessibility guidelines for Web-based products and services[14]. The systematic collection, consolidation and interpretation of guidelines is also pursued in the context of international collaborative and standardization initiatives. Another line of work relevant to Universal Access is user-centred design, which is often claimed to have an important contribution to make, as its human-centred protocols and tight design-evaluation feedback loop replace techno-centric practices with a focus on the human aspects of technology use.

At the level of implementation approaches, a proposed approach, which was first applied in the design of human computer interfaces and then generalized to the implementation of complete applications, is based on the concepts of adaptability and adaptivity, as described in the following chapter. The central idea is that the variety of possible users and contexts of use can be served only if the systems and services are able to adapt themselves automatically to the needs, requirements and preferences of every single user. The adaptation must be guaranteed at run time (adaptability) and, dynamically, during interaction (adaptivity). Adaptation to users is now considered an important feature of all systems and services in ICT, even if in most cases this general claim is considered to be satisfied by introducing some form of personalization under the control of the user.

Unfortunately, in ICT there is not yet general consensus about what Design for All is, and there is not yet enough knowledge and interest about developments in the Information Society (apart from which is directly testable in everyday present life). This is particularly strange, because Design for All by definition can be applicable only to products to be developed, that is to the future. However, if the development is toward an agreed upon model (Ambient Intelligence), since the new society will not materialize in a short time, but there will be a (probably long) transition, it makes sense to try and find out the main characteristics of the future generations of technology and services and applications in order to influence them.

[14] http://www.w3.org/WAI/

2.3.4. Design for All versus Assistive Technology

It is commonly accepted, also officially in political European documents (European Council, 2000), that the emerging Information Society will have to be universally accessible to all citizens. This includes people who have functional, sensorial or mental limitations due to impairments or age. In the same documents, explicit reference is made to the need to develop the new society (technology and the corresponding services and applications) using a Design for All approach. As discussed before, within the context of Universal Access, Design for All has a broad and multidisciplinary connotation, and refers to the design of interactive products, services and applications that are suitable for most of their potential users without the need for any modification.

This change of paradigm as compared with the Assistive Technology approach, which is based on the adaptation - on behalf of people with disabilities - of systems and services produced for the general market, is considered by many people working in the sector to be too ambitious and even dangerous. This is because it could jeopardise, at least in the short term, advances toward inclusion made by groups of people with activity limitations.

However the Design for All approach is not "against" Assistive Technology, the conceptual and technological environment in which adaptations and add-ons for people with disabilities have been traditionally developed. The variety and complexity of individual situations are such that, at least in the short-to-medium terms, it will not be possible and/or economically viable to accommodate all necessary features within the adaptability space of a single product. What will probably be necessary is an expansion of the Assistive Technology sector toward the use of advanced technology, as was the case twenty years ago when new technology (e.g. voice synthesis and recognition) was primarily applied in the environment of rehabilitation, and a shift from the adaptation of products designed for an average user to an adaptability built in at design time. Probably, the transition from Assistive Technology and Design for All will have to be established upon a careful trade-off between built in adaptability and a posterior adaptations, on the basis of economic and functional criteria.

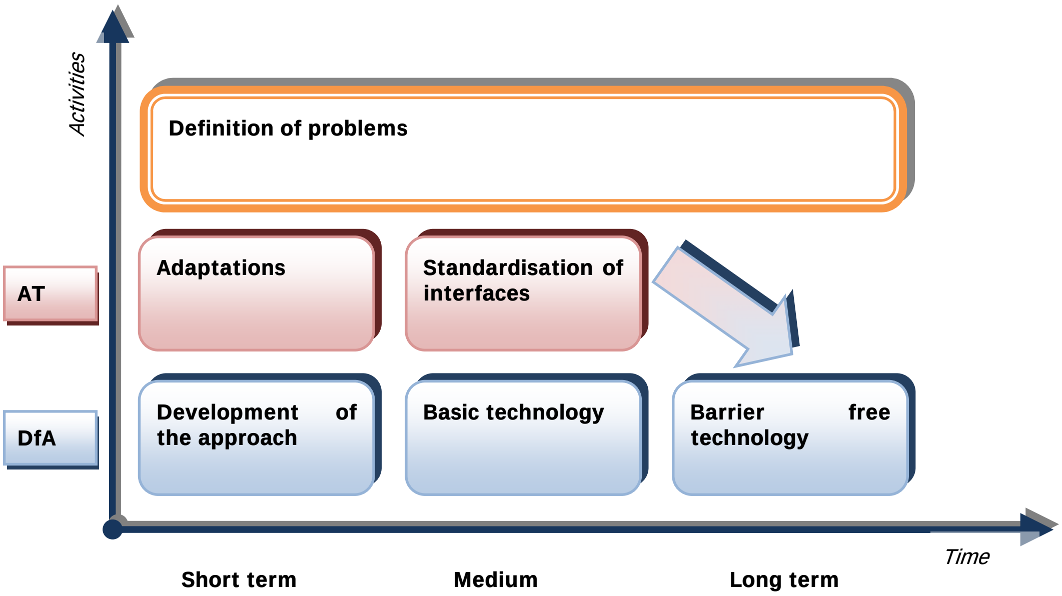


Figure 2.5: Convergence between Assistive Technology and Design for All

The point made in this paper is that the two approaches must be considered as complementary: they should converge towards the creation of a more accessible society through the continuous redefinition of problems in accordance with the developments in Assistive Technology and Design for All, which are aimed at producing a barrier-free technology, as sketched in Figure 2.5. Complementarity and convergence are intended not only in the trivial meaning that the individual characteristics of users are so varied that it will be very difficult (if not impossible?) to actually integrate the requirements of all individuals within the specifications of new products and services, but also in the more general meaning that the lessons learned in Assistive Technology will be fundamental in shaping the new environment. The integration of the two approaches will make the use of Assistive Technology in Design for All environments simpler and more effective.

The emerging situation is thus discussed with an evolutionary approach, showing how the Ambient Intelligence approach should be supported by a technology which, in the short term, will enhance the possibilities offered by Assistive Technology, merging in the medium term into accessible systems and services and, in the long term, into an intelligent environment, which has the potential of being usable by most users if their needs are proactively taken into account during the design phase. Through the previous approach, Design for All should emerge not as an abstract and politically enforced methodology for the development of the Information Society, but as a necessary and efficient approach for maximising the potential advantages in introducing new technologies and for minimising inherent risks of the increasing segregation of certain groups of people. It will also become clear that the need and efficiency of this approach are essentially due to the fundamental fact that the core of the Design for All approach is the concept that the user is the essential guide in design.

3. The present situation

3.1. Introduction

This chapter deals with a short summary of the main functional characteristics of present ICT and the available Assitive Technology. This has two purposes. The first is to discuss accessibility of ICT as such and with adaptations or augmentation through the support by Assitive Technology. The second is to use the summary for commenting the fact that present Assitive Technology is not very innovative and there are gaps between its capabilities and those made possible by the use of most advanced ICT.

The chapter is divided into three sections. The first presents the main functional characteristics of ICT technology, including telecommunications infrastructures (networks), information technology and telecommunication equipment, and services and applications presently available on the market for the general public. It is not intended to describe technical details or to constitute an exhaustive review of available technologies, but to constitute a sufficient description to discuss about their possible role to favour or hinder the possibilities for communication, access to information and environmental control of different groups of people. This is supposed to allow the identification of technologies that can be used as such and can support specific users, or must be adapted, or need the integration with Assitive Technology products.

The second section reviews the state of Assitive Technology, with reference to the classification of the International Organisation for Standardisation (ISO). The main functionalities of the different Assistive Technology categories are reviewed and possible improvements with the use of ICT are considered.

Finally, the possible impact of Design for All approaches is shown through the report of the results of projects supported by the European Union in a time span of about 15 years. In the report the main achievements that have made possible the implementation of adaptable and adaptive systems, services and applications are reported, as an example of the fact that Design for All is also possible with present technology.

3.2. Review of ICT today

3.2.1. Introduction

In this document it is obviously impossible to review Information and Communications Technology (ICT) in all its aspects, due to the complexity and heterogeneity of this technological field produced by the merging of different industrial and application sectors, i.e. information technology, telecommunication and media industry. The term ICT encompasses many aspects of computing, communications and technology, and now covers many fields. It also has a considerable share in the world market (Figure 3.1).

The aim here is not to give a complete review of ICT, but to identify some general features, useful to carry on a discussion about the implications that the present status and the ongoing developments in ICT may have on socio-economic inclusion of all citizens, including people with activity limitations, in the emerging Information Society. This is also the reason why the section does not follow the classical and/or academic structuring of the ICT field, but organises the material in a way that is considered useful for the purpose of evaluating the impact of ICT on eInclusion. It is therefore assumed that ICT can be seen as the sum of the following three macro categories:

- telecommunication infrastructure;
- devices;
- software.

These macro categories are themselves complex and heterogeneous. When dealing with eInclusion, they have all to be considered, because they all have an impact (either taken singularly or in connection with each other) on several aspects related to the everyday lives of all people.

For example, even a simple phone call is the result of the combination of a telecommunication infrastructure (a fixed or mobile telephony network), a physical device (a wired or mobile phone) and a software for managing the call (choosing the number from the contact list or interacting with an automated centre for booking a seat on train). Each of these levels may present aspects that facilitate or create barriers to users. For example, as far as networks are concerned, data rate may prevent from smooth delivery of certain types of information, such as movies or streaming audio. Devices may be difficult or impossible to use by certain groups of people, for example because of limited display width. Services may be implemented so as to contain barriers for access by people with activity limitations.

The following sections constitute an attempt to outline key points relevant to the aspects identified above, which may have an impact on eInclusion.

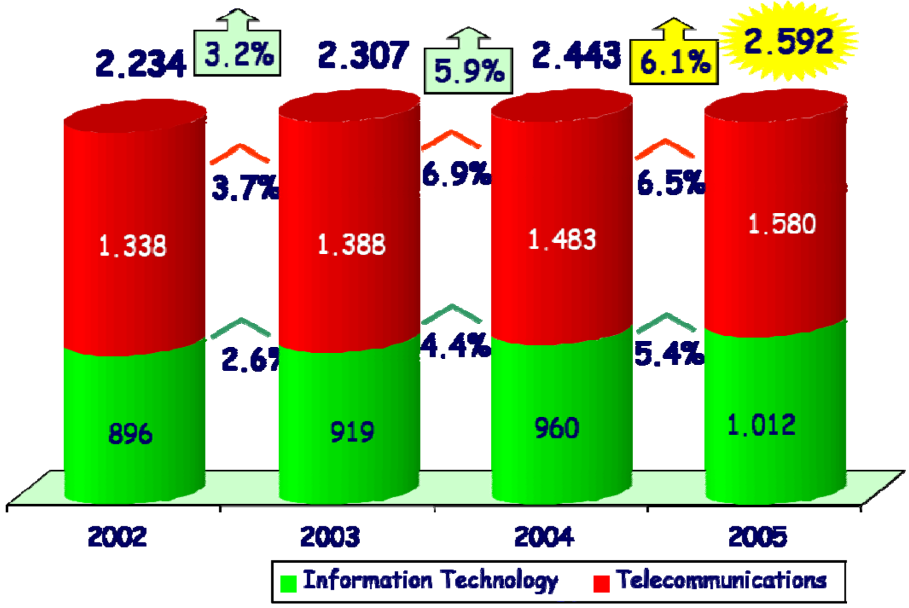


Figure 3.1: Size of the ICT market in years 2002-2005. Numbers are referred to the whole world and are in Billions of dollars. Percentages represent annual growth (Assinform Report, 2006).

3.2.2. Infrastructure

ICT Infrastructure will be categorized in this section according to some parameters relevant to their impact on eAccessibility:

- Wired or wireless;
- Data rate (in ICT the term refers to the number of bits that are conveyed or processed per unit of time, and is generally in bits per second);
- Range or distance (for wireless networks).

These categories are important in order to reason on what telecommunication infrastructure (and correspondingly what cost) is needed for supporting possible services that can be useful for the inclusion of people in the society. Apart from the obvious difference between infrastructures allowing fixed or mobile services, the data rate is important for understanding the quality of the media components (e.g. pictures) that a service can deliver, i.e. for evaluating what is the type of infrastructure needed to support a service. For example, a service intended to support distance conversation between people who cannot hear through sign languages must be offered on networks with sufficient data rate to transfer streaming video smoothly.

3.2.2.1. Wired networks and data technologies

This section contains a list of networks capable of transferring data through wires.

Public switched telephone network (PSTN) is an analog network meant originally for supporting the world's public telephony. Digital data can be transmitted with a modem with a data rate up to 56Kbit/s.

Integrated Services Digital Network (ISDN, introduced in the late 1980's) is a telephone network system for digital transmission of voice and data over ordinary telephone copper wires having higher speed (up to 128 Kbit/s) and quality than analog systems (PSTN).

Digital Subscriber Line (DSL) is a data communications technology that enables faster data transmission over copper telephone lines than a conventional voiceband modem can provide. Maximum data rate is nowadays 20Mbit/s.

Optical fibre communication is a method of transmitting information from one place to another by sending light through an optical fibre. It is used when broad bandwidth or spanning longer distances is required, with suitable repeaters. Maximum data rate is typically 10Gbit/s.

Type	Data rate	Typical use
PSTN	56Kbit/s	Voice, data (fax)
ISDN	128Kbit/s	Voice, data (fax)
DSL	20Mbit/s	Multimedia contents, voice (over IP)
Optical fibre	10Gbit/s	Huge amounts of data for commercial telecom systems, intercontinental backbones.

Table 3.1 Summary of the main characteristics of wired networks, and of their typical use

3.2.2.2. Wireless networks and data technologies

Global System for Mobile Communications (GSM)[15] is the most popular standard for mobile phones in the world, covering about 82% of the global mobile market. Data rate is 9.6Kbps.

General Packet Radio Service (GPRS) is a data service available to users of GSM. GPRS data are billed per kilobyte of information transferred or received, while circuit-switched data connections, e.g. GSM, are billed per second, because when no data are transferred, the data rate is unavailable to other potential users. Typical data rate is 72.4Kbps.

Enhanced Data rates for GSM Evolution (EDGE) or **Enhanced GPRS** (EGPRS) is a digital mobile phone technology that allows increased data transmission rates and reliability. It is generally classified as the unofficial standard 2.75G. Maximum theoretical data rate is 473.6Kbit/s.

Universal Mobile Telecommunications System (UMTS)[16] is one of the third-generation (3G) cell phone technologies. UMTS supports up to 14.0Mbit/s data rates although at the moment users can expect a transfer rate of up to 384Kbit/s, and 3.6Mbit/s for HSDPA devices.

[15] See http://www.gsmworld.com/ for details, last visited on 18 December 2008.

Wi-Fi[17] is a wireless technology intended to improve the interoperability of wireless local area network products based on the IEEE 802.11 standards. Three revisions have been released (see Table 3.3). Wi-Fi allows connectivity in peer-to-peer mode enabling devices to connect directly with each other. Typically Wi-Fi is used by an end user to access their own network, which may or may not be connected to the Internet.

Wi-Max[18] is a term coined to describe standard, interoperable implementations of IEEE 802.16 wireless networks. WiMax is a long-range system, covering distances of the order of many kilometres, and typically uses licensed spectrum to deliver a point-to-point connection to the Internet from an Internet Service Provider to an end user. Theoretical maximum data rate is approximately 75Mbps per channel ~50km.

Type	Data rate	Typical use
GSM	9.6Kbit/s	Voice, SMS
GPRS	72.4Kbit/s	Voice, SMS, MMS, Internet (basic services)
EDGE	473.6Kbit/s	Voice, SMS, MMS, multimedia contents, Internet (multimedia sites).
UMTS	384Kbit/s – 3.6Mbit/s	Voice, SMS, MMS, multimedia contents, Internet (rich multimedia sites).
Wi-Fi	~20Mbit/s, ~35m distance	Wireless local area networks
Wi-Max	~75Mbit/s per channel, ~ 50Km distance	Connection to the Internet from an ISP to an end user
Bluetooth	Up to 2.1 Mbit/s, ~ 1, 10, 100m (depends on power consumption)	Connection between devices such as mobile phones, laptops, PCs, printers, digital cameras, and video game consoles
ZigBee	Up to 250 kbit/s per channel in the 2.4 GHz band, range is between 10 and 75m	Current focus is to define a general-purpose, inexpensive, self-organizing, mesh network that can be used for industrial control, embedded sensing, medical data collection, smoke and intruder warning, building automation, home automation, etc.

Table 3.2 Summary of the main characteristics of wireless networks and their typical use.

ZigBee[19] is a high level communication and applications protocol using small, low-power digital radios based on the IEEE 802.15.4 standard for wireless networks. It is targeted at RF applications that require a low data rate, long battery life, secure networking.

Bluetooth[20] wireless technology is a short-range communications system intended to replace the cables connecting portable and/or fixed electronic devices. The key features of Bluetooth wireless technology are robustness, low power, and low cost. The range depends on one of three power-classes and can be: 1 meter, 10 meters, 100 meters. The data rate is up to 2.1 Mbit/s, for Bluetooth version 2.1.

---

[16] See http://www.umts-forum.org/ for details, last visited on 18 December 2008.
[17] See http://www.wi-fi.org/ for details, last visited on 18 December 2008.
[18] See http://www.wimaxforum.org for details, last visited on 18 December 2008.
[19] See http://www.zigbee.org/ for details, last visited on 18 December 2008.
[20] See http://www.bluetooth.com for details, last visited on 18 December 2008.

Standard	Data rate (Typical)	Data rate (Max)	Indoor range
802.11a (1999)	23 Mbit/s	54 Mbit/s	~35 m
802.11b (1999)	4.5 Mbit/s	11 Mbit/s	~35 m
802.11g (2003)	19 Mbit/s	54 Mbit/s	~35 m
802.11n (2009)	74 Mbit/s	248 Mbit/s	~70 m (2 streams)

Table 3.3 IEEE 802.11 standards.

Future standards

IEEE 802.20 Mobile Broadband Wireless Access (MBWA). The mission of IEEE 802.20 is to develop the specification for an efficient packet based air interface that is optimized for the transport of IP based services.

IEEE 802.22 aims at constructing Wireless Regional Area Network (WRAN) utilizing white spaces (channels that are not already used) in the allocated TV frequency spectrum.

Table 3.2 and Figure 3.2 summarize the main characteristics of the mobile infrastructure.

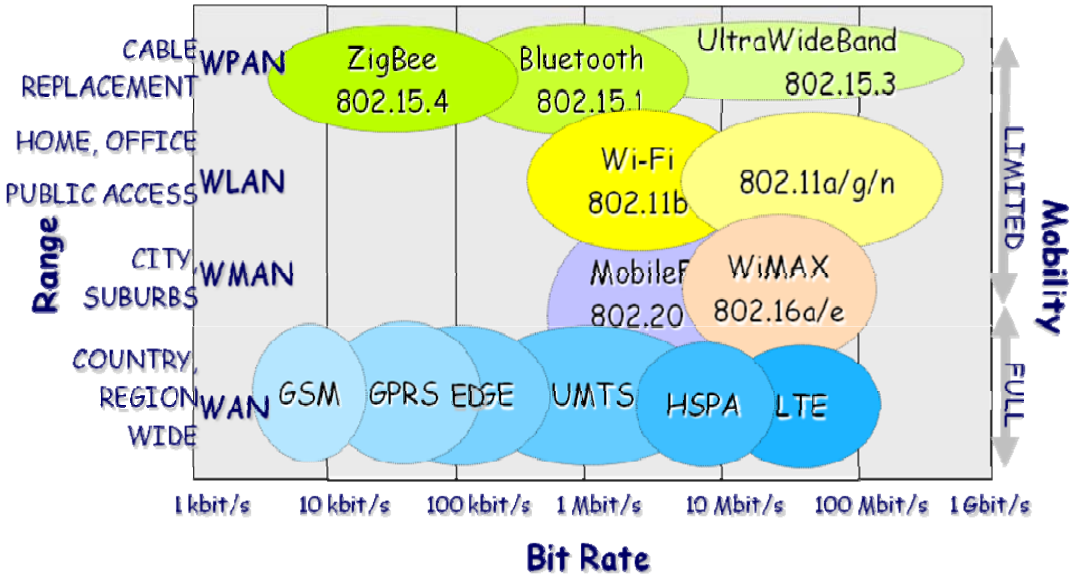


Figure 3.2: Summary of characteristics of wireless networks.

Figure 3.3 shows some indicators of use of ICT and the penetration of broadband in Europe. It can be used, for example, to have an idea of the possible penetration of services that need the support of a wideband connection and the need of services that can be used without knowledge of computer science.

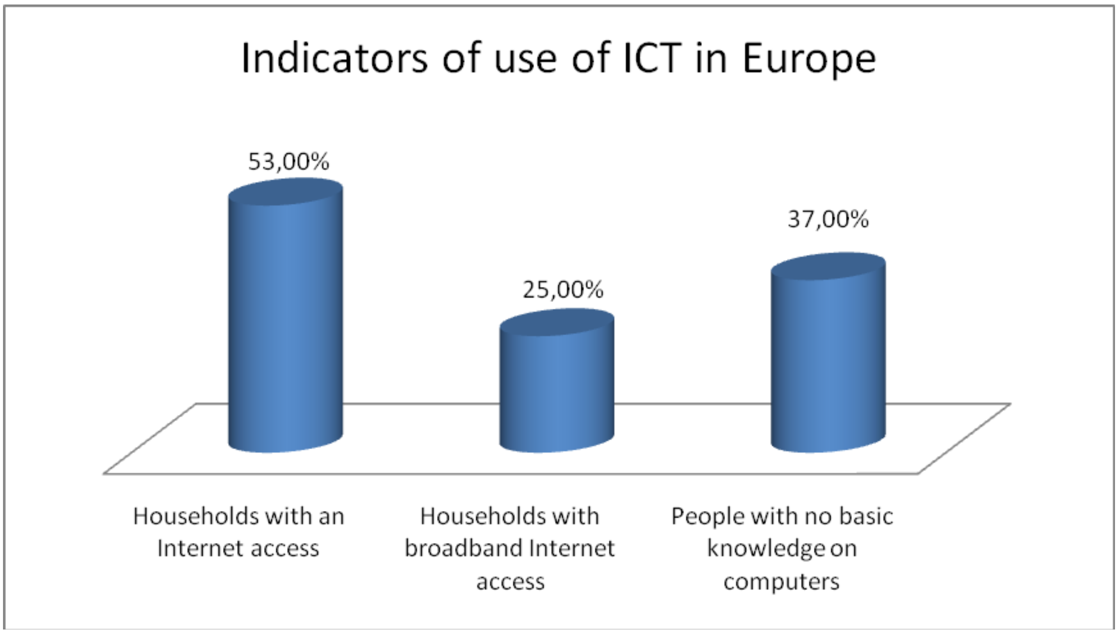


Figure 3.3: Indicators of the use of ICT in Europe. Source: Eurostat.

3.2.2.3. Digital television

Digital television (DTV) is a telecommunication system for broadcasting and receiving moving pictures and sound by means of digital signals, in contrast to analog signals used by traditional TV. DTV broadcasts digitally compressed data and requires decoding by a specially designed television set, or a set-top box, or a PC fitted with a television card. This technology allows interaction between the TV watcher and the DTV system.

3.2.2.4. Positioning systems

Positioning systems allow to determine one's position on the surface of the Earth by trilateration of microwave signals from satellites. Receivers of signals are capable to act as an aid to navigation and to calculate local velocity and orientation.

The main positioning system available is the **Global Positioning System** (GPS), utilizing a constellation of at least 24 satellites orbiting at an altitude of 20,200 km and having a precision of about 6 meters, which can increase up to 3 meters with the Wide Area Augmentation System[21] (WAAS) or the European Geostationary Navigation Overlay Service[22] (EGNOS). The receiver must "see" the satellites and, therefore, the system is usable only in open spaces.

The **Galileo** positioning system is a planned Global Navigation Satellite System, to be built by the European Union (EU) and European Space Agency (ESA). Galileo is intended to provide more precise measurements to all users than available through GPS.

3.2.3. Devices

Up to recent times, devices to interact with people and exchange data were traditionally limited to the telephone (voice), desktop PCs, and notebooks (Internet and e-mail). Radio and television were the

[21] http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gnss/waas/ , last visited on 18-Dec-08.
[22] http://www.esa.int/esaNA/egnos.html, last visited on 18-Dec-08

only means to receive information. Mobile networks, miniaturization of electronic equipment and the increase in multimedia contents have enriched the variety of devices used to access and exchange information. This section gives a short review of the main devices used today to interchange data across the networks described in the previous section, which include:

- Desktop PCs, notebooks;
- PDA – Telephones - GPS receivers;
- Set-top boxes, satellite receivers;
- Cameras and video – cameras;
- MP3 players.

The focus is on typical use and implications on eAccessibility.

3.2.3.1. Desktop and Notebooks

These devices theoretically do not pose barriers to information access, using up to date Assitive Technology adaptations. Technology is rather stable and mature. Problems can only be introduced by poorly designed software applications, which do not meet one of the international guidelines available.

These devices, which were once used only as instruments for working, are now becoming popular for interpersonal communication and for accessing public utility services, thus having a precious role for eInclusion in the Information Society.

A PC can be used to write an email, to participate in a chat and to make a video phone call (these functions requiring a connection to the Internet and a number of peripherals such as a video camera, a microphone and speakers). Future scenarios foresee that functions will remain the same, but peripherals will be embedded in the ambient. For example keyboards could be inserted or projected on the desk and screens on walls.

3.2.3.2. PDA – Telephones – GPS receivers

While telephones and PDAs were once separate devices, there is now the tendency to incorporate their functionalities in a single device (often also having the capabilities of a GPS receiver and MP3 readers).

They can in principle be used to have the same functionalities and access the same services as with PCs, using mobile networks. In practice, limitation in screen sizes and the lack or limited size and complex structure of keyboards still pose problems of accessibility to users, at the physical level. Also, problems arise from the fact that operating systems running on mobile devices often present limitations both from the user’s and the developer’s perspective. From the one side they are not so rich in functionalities for the final users. On the other side, developers encounter difficulties in producing usable and accessible software for a PDA or a phone, due to limitations in Software Development Kits for mobile devices (for example, limited support for voice recognition).

Apart from these considerations, PDAs and telephones allow users to have at their disposal a series of services and possibilities of interpersonal communication facilities anywhere and at anytime. For example services are available to localize people; mobile devices having a camera also allow people who cannot hear to count on an interpreter of sign language in any situation.

3.2.3.3. Set-top boxes, satellite receivers

In the last few years television has evolved from a monodirectional medium used only to receive information to become a bidirectional medium which can be used for interaction with a number of services.

Set-top boxes and satellite receivers are devices able not only to decode signals transmitted by DTV, but also to provide PC-like functionalities, enabling interaction capabilities between the end-user and the broadcaster through the use of a return path. Being the television receiver certainly the most popular home electronics device in the world, set-top boxes constitute a mean to introduce a computer and a series of potentially useful services in the houses of people that are not so familiar with traditional PCs, thus having a potentially important impact on eInclusion.

3.2.3.4. Other devices and/or sensors

A Radio-frequency identification (RFID) tag[23] is an object that can be applied to or incorporated into a product, animal, or person for the purpose of identification using radio waves. RFID tags can be *passive*, *active*, or *semi-passive* (also known as *battery-assisted*). Passive tags require no internal power source, thus being pure passive devices (they are only active when a reader is nearby to power them), whereas semi-passive and active tags require a power source, usually a small battery.

While one of their main use is in inventory tracking and management in large supply chains, they are also used experimentally e.g. to give guidance for blind people: in this case, passive RFIDs are embedded into the ground and blind people are provided with a special version of their walking stick that is used to “read” information from RFIDs.

3.2.4. Software

To have a full picture of the ICT panorama it is necessary to introduce some basic concepts about software, because this constitutes a core element to allow for interaction between users and services, through devices and networks.

As the subject is wide and complex, only some insights will be given in this section, again, with a view to issues related to eInclusion and eAccessibility. Examples will be discussed about Operating Systems and the Web, because these topics are considered of key importance: Operating Systems constitute the core of every system and eAccessibility and eInclusion strongly depend on their architecture as these have to provide developers with instruments (such as Software Development Kits) to implement usability and accessibility features; the Web is discussed because it is one of the main sources for delivery and sharing of information.

For a complete classification of software, the North American Product Classification System[24] (NAPCS) can be considered.

3.2.4.1. Operating systems

Modern operating systems have a series of built in features to cope with accessibility issues. In the following sections, a brief description of those coming with Microsoft Windows Vista will mainly be made, due to the wide diffusion of the Microsoft Windows systems (Figure 3.4). Also an insight will be provided on accessibility features of Linux and Mac OS.

[23] See http://en.wikipedia.org/wiki/RFID, last visited on 18 December 2008.
[24] http://www.statcan.ca/english/Subjects/Standard/napcs/napcs.htm, last visited on 2008-12-18

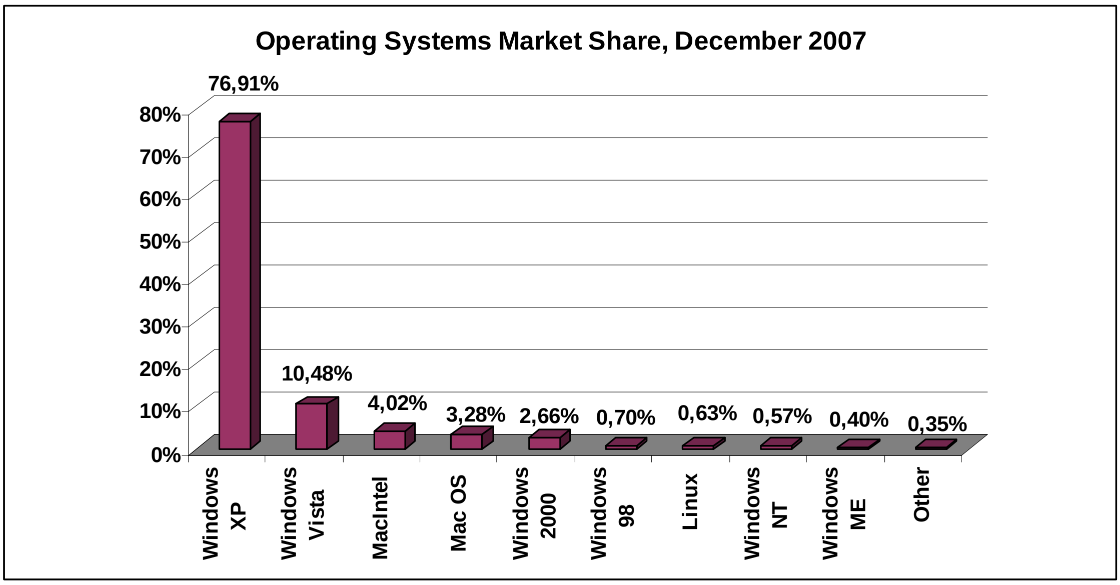


Figure 3.4: Operating systems market share, as of December, 2007. Data source: http://marketshare.hitslink.com/.

3.2.4.1.1. Microsoft Windows Vista accessibility features

Microsoft reports that the company invested a substantial amount of resources to better understand the needs of people who experience a wide range of physical challenges that can impact their computer use. As a result, their latest operating system Windows Vista includes built-in accessibility settings and programs that make it easier for computer users to see, hear, and use their computers. The accessibility settings and programs in Windows Vista (see Table 3.4, more details on the home page for Accessibility of Microsoft products[25]) are particularly helpful to people with visual difficulties, hearing loss, limited sensory or motor ability of the upper limbs, or reasoning and cognitive issues. Major accessibility improvements in Windows Vista are the Ease of Access Center and state-of-the-art speech recognition and magnification capabilities.

Features	Description
Ease of Access Center	Provides a centralized location where accessibility settings can be adjusted and accessibility programs can be managed.
Speech Recognition	Enables users interact with the computer using only voice while maintaining, or even increasing, productivity.
Magnifier	Magnifies part of the screen, making it easier to see enlarged items on screen.
Narrator	A text-to-speech program that reads aloud on-screen text and describes some events (such as error messages) that happen while using the computer.
On-Screen Keyboard	A visual, on-screen keyboard with all the standard keys that can be used instead of a physical keyboard. On-Screen Keyboard also lets users type using an alternative input device.
Keyboard shortcuts	Use keyboard shortcuts as an alternative to the mouse. Keyboard shortcuts can be found in the menus of programs. If a letter is underlined on a menu, that usually means pressing the ALT key in combination with the underlined key has the same effect as clicking the menu item.
Mouse Keys	Instead of using the mouse, the arrow keys on the numeric keypad can be used to move the pointer.

[25] http://www.microsoft.com/enable/ , last visited on 2008-12-18

Sticky Keys	Instead of having to press multiple keys at once (such as when the Ctrl, Alt, and Delete keys must be pressed simultaneously to log on to Windows), one key at a time can be pressed when Sticky Keys is turned on.
Filter Keys	Ignores keystrokes that occur in rapid succession and keystrokes that are held down for several seconds unintentionally.
Visual Notifications	Replace system sounds with visual cues, such as a flash on the screen, so system alerts are announced with visual notifications instead of sounds.
Captions	Turn on text captions for animations and video.
Replacement for SerialKeys	Windows Vista does not include SerialKeys. In previous versions of Windows, Serial Keys provided support so that alternative input devices, such as augmentative communication devices, could be plugged into the computer's serial port. For individuals that used these devices, it is important to install an alternative solution prior to upgrading to Windows Vista. Recommended solutions: AAC Keys and SKEYS from Eyegaze.

Table 3.4 Accessibility features in Microsoft Windows Vista.

Microsoft has also provided their latest browser Internet Explorer 7 coming with Vista with accessibility features reported in Table 3.5. In general, Internet Explorer claims to have enhanced compatibility with Assistive Technology products as well as improved keyboard access.

As for the instruments to develop Windows applications, the Win32 API, through the Active Accessibility SDK[26], puts at the disposal of software developers a set of accessibility features to make it easier for persons with activity limitations to use computers.

Features	Description
Zoom in on a Web page	Zoom in on a Web page to magnify text, images, and controls on the page. Change the zoom level with the magnifying glass icon on the bottom right corner of each Internet Explorer 7 window, or, from the Page menu. Choose 100%, 125%, or 150%, or, specify magnification up to 1,000%.
Choose colours used on Web pages	Make Web pages easier to see by changing the text, background, link and hover colours. IE 7 supports the system link colour, so high contrast mode and colour preferences chosen in the Windows operating system will work properly in IE 7.
Change text size on Web pages	Change Web page text size from smaller, smallest, medium, larger, or largest.
Choose fonts used on Web pages	Choose the font style and size used on Web pages and documents to make them more legible.
Choose accessibility settings for Web pages	Choose to ignore colours, font styles, and font sizes specified on Web pages to make the pages easier to see. Documents can also be formatted using a personal style sheet.
Format Web pages using a custom style sheet	Make Web pages easier to see and work with by adjusting several accessibility settings, browsing, multimedia, and printing settings in Internet Options.

[26] http://msdn2.microsoft.com/en-us/library/ms697707.aspx , last visited on 2008-12-18

Choose advanced settings	**Advanced accessibility settings** are available, including: 1. Always expand ALT text for images 2. Move system caret with focus/selection changes 3. Reset text size to medium for new windows and tabs 4. Reset text size to medium while zooming (takes effect after you restart Internet Explorer) 5. Reset zoom level to 100% for new windows and tabs **Use smooth scrolling and Enable page transitions** Turned on, this option allows a special type of scrolling to display content at a predetermined speed. Turned off, screen readers will continue to read links correctly even when the next link is off the current screen, and voice recognition programs may perform better as well. Left on, screen readers will sometimes read part of the next link, and sometimes read extraneous information along with the next link. **Show pictures, Play animations, and Play videos** Specify if you want to turn off or show pictures, animations, and videos. If you have low vision, you might want to clear these check boxes to improve performance. If you are sensitive to screen flashing, you might also want to clear these check boxes. **Play sounds** Turned on, music and other sounds included in Web pages will play when the pages are displayed. Turned off, screen readers will be better able to be heard without distracting computer sounds. Turning this option off can also benefit people who want to reduce sound distractions. **Print background colours and images** Turned on, this option allows background colours and images to print when you print a Web page. Turned off, print legibility is often improved when background images are eliminated from the printed copy.

Table 3.5 Accessibility features in Microsoft Internet Explorer 7.

3.2.4.1.2. Linux accessibility

The Linux Operating System has become popular mostly due to the reason that it is open-source, thus offering an inexpensive and efficient solution for all users.

A number of accessibility-related tools have existed for the Linux command line environment, but so far, GUIs and graphical desktops on Linux have remained inaccessible to users with various activity limitations.

However, recently, several projects are in the process to improve the accessibility on Linux, even if the situation is different due to the heterogeneity in Linux graphical desktop environments. For example, the GNOME Accessibility Project[27] focuses on the accessibility of a very popular Linux desktop called GNOME and has worked to build improved accessibility features into GNOME and to create a screen reader, Braille output software, and a sophisticated on-screen keyboard. Moreover, a small on-line community of developers and other volunteers named KDE Accessibility Project[28] has been established to ensure that the KDE desktop is accessible to all users, including those with physical or sensorial impairments.

A more comprehensive and always updated overview of Linux accessibility, including lists of Linux AT software products, is available at the Linux Accessibility Resource Site[29].

3.2.4.1.3. Mac OS accessibility

Apple is committed to including usability features "by design" in their Mac OS X operating systems. However, Mac OS X also integrates a wide variety of characteristics and technologies specifically designed to favour accessibility for users with activity limitations. In the Apple lexicon, they are

[27] http://developer.gnome.org/projects/gap/ , last visited on 2008-12-18
[28] http://accessibility.kde.org/ , last visited on 2008-12-18
[29] http://larswiki.atrc.utoronto.ca/wiki/ , last visited on 2008-12-18

termed “Universal Access” and can be used in conjunction with a variety of applications from Apple and other developers.

Accessibility Technologies in Mac OS X include:

- Zoom;
- Full keyboard navigation;
- Sticky Keys and Slow Keys;
- Mouse Keys;
- Closed-Captioning in QuickTime;
- Visual alert;
- Spoken items;
- Talking alerts;
- Speech recognition;
- Display adjustment.

More details can be found on the Apple accessibility web site[30].

It is to be remarked that new ways of interaction are also being introduced by Apple in other innovative products like the iPhone, which bring new possibilities for making user interfaces of mobile devices accessible to users with disabilities.

3.2.4.1.4. Mobile OS

The situation is different for Operating Systems running on mobile devices. For example, Symbian and Windows Mobile do not include analogue accessibility features as those present on OS’s for desktops. However, they allow users to install on their portable devices third party Assistive Technology software, such as screen readers.

3.2.4.2. The World Wide Web

The World Wide Web is a system of documents, accessed via the Internet, that contain text, images, videos, and other multimedia and are connected between them through hyperlinks.

3.2.4.2.1. The Web: what’s new in Web 2.0?

One of the most interesting phenomena regarding the web is represented by Web 2.0, also called the wisdom Web, people-centric Web, participative Web, and read/write Web (Murugesan, 2007). The term "Web 2.0" was born in a conference brainstorming session between O'Reilly and MediaLive (O’Reilly, 2005) and does not refer to an update to Web technical specifications, but to changes in the ways software developers and end-users use the web and the internet *as a platform*.

Although there is not full agreement on a definition, it is a fact that Web 2.0 is perceived as a second phase in the web’s evolution, in which web based service have the characteristic of aiming to facilitate collaboration and sharing between users, letting them engage in an interactive and collaborative manner, giving more emphasis to social interaction and collective intelligence.

[30] http://www.apple.com/accessibility/ , last visited on 2008-12-18

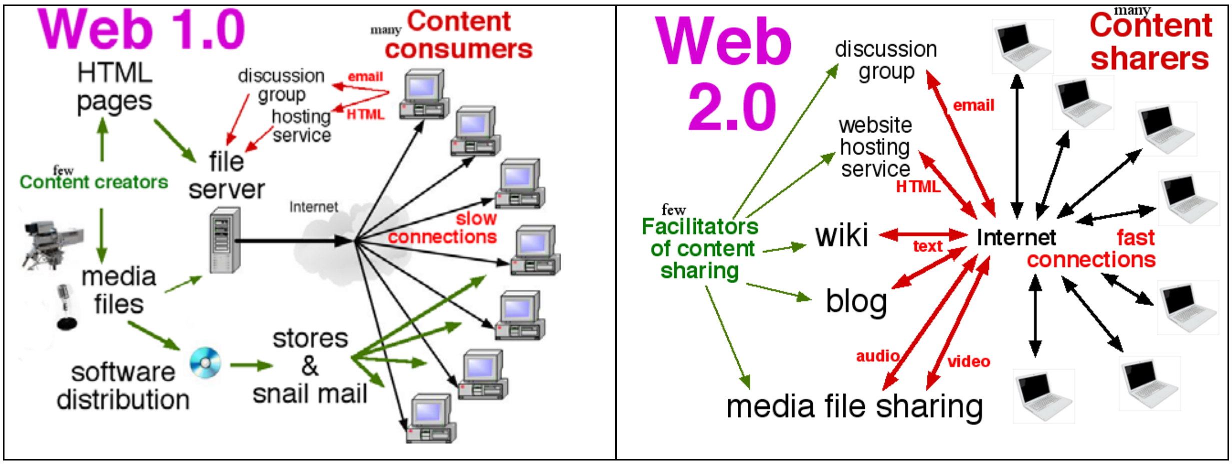


Figure 3.5: Comparison between Web 1.0 and Web 2.0 (from http://en.wikiversity.org/wiki/Web_2.0.

Web 2.0 websites represent more than just a searchable container for information. They can make the network e.g. a platform for computing, allowing users to run software applications entirely through a browser (as in Google Docs[31]). These sites may have an "architecture of participation" that encourages users to add value to the application as they use it. This is clearly different from what happens in traditional websites, in which visitors can only view information, while contents can only be added and modified by the site's administrator.

Common characteristics found in Web 2.0 websites are:

- Syndication and aggregation of data in RSS or Atom feeds;
- Human readable URLs;
- Folksonomies, also known as collaborative tagging, social indexing, meaning collaboratively creating and managing tags to annotate and categorize content in the form of tags or tagclouds, for example;
- Wiki or forum software to support user generated content;
- Weblog publishing;
- Mashups, merging content from different sources.

Some examples of Web 2.0 sites are:

- Google Docs, which makes the internet a platform for authoring documents and spreadsheets and allows to share them with users within a community;
- iTunes[32], mainly because of its music-store portion;
- Flickr[33] and Panoramio[34], which benefit from their shared photo-database and from its community-generated tag database;
- eBay[35], Wikipedia[36], del.icio.us[37], Skype[38], Dodgeball[39], which enable sharing human connections and establishing networks through Web 2.0, growing in effectiveness the more people use them.

---

[31] http://docs.google.com/ , last visited on 2008-12-18
[32] http://www.apple.com/it/itunes/store/music.html , last visited on 2008-12-18
[33] http://www.flickr.com/ , last visited on 2008-12-18
[34] http://www.panoramio.com/ , last visited on 2008-12-18
[35] http://www.ebay.com/ , last visited on 2008-12-18

3.2.4.2.2. Rich Internet Applications

Many (but not all) Web 2.0 applications are supported by a series of new generation web based technologies that have existed since the early days of the web, but are now used in such a way to exploit user-generated content, resource sharing and interactivity in a more sophisticated and powerful way (Knights, 2007), giving rise to the so called Rich Internet Applications (RIA).

Techniques such as AJAX have evolved that have the potential to improve the user-experience in browser-based applications. AJAX is not a new technology itself; it is based on several technologies, and combines them in a new powerful ways. AJAX includes:

- dynamic display and interaction using the Document Object Model;
- data interchange and manipulation using XML and XSLT;
- asynchronous data retrieval using XMLHttpRequest;
- JavaScript, binding everything together.

From a practical point of view, it allows a web-page to request an update for some part of its content, and to alter that part in the browser, without needing to refresh the whole page at the same time. This increases the responsiveness of applications and facilitates interaction of users with data stored on servers, which in Web 1.0 happened exclusively through the use of HTML forms and complete page reloads.

Common techniques used in Web 2.0 also include Adobe Flash[40] and the recently introduced Adobe Flex[41], which are both powerful application development solutions for creating and delivering RIAs across the web. They enable enterprises to create multimedia-rich applications that enhance user experience, changing the way people interact with the web.

3.2.4.2.3. Web 2.0 and eInclusion issues

Accessibility of web sites has traditionally been handled through guidelines or national laws.

One of the most well known organizations involved in establishing a set of guidelines for accessibility for the web is the Web Accessibility Initiative (WAI), which is part of the World Wide Web Consortium (W3C). WAI has published in 1999 the well known Web Content Accessibility Guidelines (WCAG) 1.0[42] which explain how to make web content accessible to people with activity limitations. WCAG 1.0 are to be replaced with an updated version reflecting technological changes happened since 1999, the Web Content Accessibility Guidelines 2.0 (WCAG 2.0)[43], which are almost complete but, up to the delivery of this document, are officially still in the status of *W3C Working Draft*.

The WAI guidelines have been reworked and taken as an inspiration to publish national laws to regulate the accessibility of web sites in a number of countries.

---

[36] http://wikipedia.org/ , last visited on 2008-12-18
[37] http://del.icio.us/ , last visited on 2008-12-18
[38] http://www.skype.com/ , last visited on 2008-12-18
[39] http://www.dodgeball.com/ , last visited on 2008-12-18
[40] http://www.adobe.com/products/flash /, last visited on 2008-12-18
[41] http://www.adobe.com/products/flex/ , last visited on 2008-12-18
[42] http://www.w3.org/TR/WAI-WEBCONTENT/ , last visited on 2008-12-18
[43] http://www.w3.org/TR/WCAG20/ , last visited on 2008-12-18

Main characteristics of WCAG 2.0

WCAG 2.0 are based on *guidelines*, which are grouped into four *principles* of accessibility. These state that web content should be *perceivable*, *operable*, *understandable*, and *robust*.

Each guideline specifies a series of *success criteria*, having different level of importance (level A, double-A and triple-A). Success criteria differ from checkpoints in WCAG 1.0 in that they are designed to be clearly testable. This structure is designed to live beyond technology changes. Thus, at this level, it does not refer to any specific technology. Technology related issues are discussed in *techniques* that give some insight on how to meet WCAG 2.0. There are currently general techniques, HTML techniques, CSS techniques, and scripting techniques, and it is planned that more will come. The idea is that techniques are informative and there is no need to follow them strictly. So it is possible for anybody to develop different techniques to meet the success criteria.

Impact of RIA on eAccessibility

As AJAX relies on JavaScript, all AJAX applications require that JavaScript is available in the browser. This aspect is particularly critical as a number of laws dealing with web accessibility of web contents (for example see the Italian Ministerial Decree, July 8 2005, containing the Technical Rules of Law 4/2004[44], “Provisions to support the access to information technologies for the disabled”) require pages to be visible without the use of JavaScript, or to provide equivalent information on an alternative accessible page. This is also a priority 1 checkpoint in the WCAG 1.0.

Recent approaches such as the one adopted in the upcoming WCAG 2.0, are more flexible when dealing with the issue of scripts. In the past there was almost no support for scripting in common assistive technologies, and accessibility was achieved only if a web site worked without scripting. Nowadays, all of the major browsers and assistive technologies, such as screen readers, support scripting and requirements about scripting could be relaxed, considering the fact that they can in some cases even enhance accessibility and usability. This is why the W3C is removing restrictions on scripting languages in WCAG 2.0, as long as the site remains accessible.

Going back to AJAX, the main impact on accessibility comes from dynamic and incremental updates in web pages. From the one side, these may come unexpected to users, who may not notice that a part of the page has changed. From a second side it is to be noted that problems with asynchronous updates may be fatal for users relying on Assistive Technology (AT): in fact, updates can occur on a different area of the page than where the user is currently interacting and AT’s could fail notifying users that something on the page has changed.

Issues concerning accessibility in RIA’s are being faced by the WAI-ARIA[45] of the W3C, which has formulated a series of best practices for rich internet applications design. The WAI-ARIA tries to define what is needed to make RIA’s accessible. They analyse what is needed, what is available and what is missing. Then, they define a plan to fill the gap between what is missing and what is available.

Efforts are made to identify and mark commonly used web structures such as menus, primary content, secondary content, banner information, and other. WAI-ARIA also examines technologies to map controls, AJAX live regions, and events to accessibility Application Programming Interfaces (APIs), including custom controls used for rich Internet applications.

Regarding accessibility in Adobe Flash and Flex substantial improvements have been introduced by Adobe, who now provides developers with a robust set of accessibility features built in, including 23 accessible components, to facilitate the process of designing accessible RIAs. Flex inherits all the accessibility advantages of Flash Player 7, including support for Microsoft Active Accessibility. Also,

[44] http://www.pubbliaccesso.gov.it/normative/law_20040109_n4.htm , last visited on 2008-12-18

[45] http://www.w3.org/WAI/intro/aria.php , last visited on 2008-12-18

best practices for developing accessible applications with Flash[46] and Flex[47] are given to let users of assistive technologies access the best experience on the web.

3.2.4.2.4. Impact of Web 2.0 on eInclusion

As stated before, the main characteristic of Web 2.0 sites is that they encourage users to add value to applications as they use it.

The different patterns in which content producers and content consumers approach web systems could put groups of people at risk of being segregated from using web sites inspired by the principles of Web 2.0. For example in Web 1.0 content is usually provided by a web team counting few experienced people, and still accessibility and usability problems are often encountered. What happens if content is provided by millions of users sharing the same service? Of course they may not have knowledge on accessibility and usability.

On the other hand, sites favouring massive information sharing could be of great importance for inclusion in the Information Society. This new form of social interaction and collective intelligence brought by Web 2.0 could enable new patterns of interpersonal communication for all users. Benefits could be substantial also for people with activity limitatiions. For example, through Web 2.0 sites motor impaired users could share their experiences about accessible paths in towns: value to the application could increase as more users use it, putting their knowledge at the disposal of other users.

3.2.4.2.5. Web Content Management Systems

A Content Management System (CMS) is a software that facilitates content creation, content control, editing, and many essential functions to be performed on electronic documents. Web content management systems (WCMS), often implemented as a web application, are used to manage the content of a web site. They are meant primarily to allow a web site to grow and be updated thanks to the contribution of a potentially large community of users.

The general term WCMS embraces several kinds of software, each aimed at a different scope and specialized to fulfil different usage patterns. Some examples are wiki platforms (such as the one on which Wikipedia is built[48]), weblog platforms (such as WordPress[49]) or general purpose tools to build and maintain web sites (ranging from open source solutions such as Joomla[50], Lenya[51] or Plone[52], to high cost products such as Vignette[53] or Documentum[54]).

It is clear that web content management systems constitute the foundations of Web 2.0 applications, enabling interactive use by large groups of users. Therefore, in order to take full advantage of the power of Web 2.0, all platforms for content publishing should probably take care of accessibility issues in the document workflow. Ideally web content management systems should be designed and structured to prevent the introduction of barriers and to encourage and implement accessibility (according, for example, to WCAG 2.0) and usability features (Billi, 2004).

[46] http://www.adobe.com/resources/accessibility/flash8/best_practices.html , last visited on 2008-12-18
[47] http://www.adobe.com/macromedia/accessibility/features/flex/best_practices.html , last visited on 2008-12-18
[48] http://www.mediawiki.org/wiki/MediaWiki , last visited on 2008-12-18
[49] http://wordpress.org/ , last visited on 2008-12-18
[50] http://www.joomla.org/ , last visited on 2008-12-18
[51] http://lenya.apache.org/ , last visited on 2008-12-18
[52] http://plone.org/ , last visited on 2008-12-18
[53] http://www.vignette.com/ , last visited on 2008-12-18
[54] http://software.emc.com/products/product_family/documentum_family.htm , last visited on 2008-12-18

3.2.4.2.6. Web 3D

The Web3D Consortium[55] is a non-profit, international standards organization utilizing its broad-based industry support to develop the X3D specification for communicating 3D on the web between applications and across distributed networks and web services, with the support of ISO and W3C.

X3D has evolved from the Virtual Reality Modelling Language (VRML) and is now a royalty-free open standards file format and run-time architecture to represent and communicate 3D scenes and objects using XML. It is an ISO ratified standard that provides a system for the storage, retrieval and playback of real time graphics content embedded in applications, all within an open architecture. Features of X3D make it suitable for use in engineering and scientific visualization, CAD and architecture, medical visualization, training and simulation, multimedia, entertainment, education, and more.

The Web3D consortium maintains an extensive website of documents and links related to VRML and X3D resources, including plug-ins and browsers from many long term members and open source developers.

3.2.4.2.7. Semantic Web

In the original Tim Berners-Lee's article (Berners-Lee, 2001), the term Semantic Web described the evolution from a Web containing mainly documents for humans to read to one that included data and information for computers to manipulate. The main idea is that the Semantic Web could help integrating and retrieving information which is stored in isolate silos, in different software applications, and different places that currently cannot be connected easily.

The Semantic Web activities at W3C[56] provide web sites with standards allowing to publish internet contents in a more readily machine-processable and integratable form. A framework is defined that allows data to be shared and reused across application, comprising:

- the Resource Description Framework (RDF), an XML language for representing information about resources in the World Wide Web;
- the Web Ontology Language (OWL), designed for use by applications that need to process the content of information instead of just presenting information to humans; OWL provides a mean for describing relations between classes, cardinality, equality, richer typing of properties, characteristics of properties, and enumerated classes;
- SPARQL, a protocol and query language for semantic web data sources.

The intent is to enhance the usefulness of the Web and its interconnection capabilities through a common standard (RDF) for websites to expose information in a more readily machine-understandable and machine-processable documents "marked up" with semantic information, and then having automated agents to perform tasks for users of the semantic web using this data. Within this framework, for example, it would be possible for users to instruct their computers to search for a camera with a resolution of at least 7M pixels, an optical zoom of at least 6X, in the nearest shopping centre opened in the first Sunday of each month, offering the possibility to pay with a given credit card. This is a task that a computer cannot perform without human direction because it requires the ability to interact with heterogeneous data and information types and searching into a set of databases which are connected not by wires but by *being about the same thing*.

Although a complete deployment of Semantic Web has still to come, it is to be noted that Web standards for expressing shared meaning have progressed steadily over the past five years (Shadbolt,

[55] http://www.web3d.org/ , last visited on 2008-12-18
[56] http://www.w3.org/2001/sw/ , last visited on 2008-12-18

2006) and the slowly increasing use of ontologies in the e-science community presages an ultimate success for the Semantic Web.

3.2.5. ICT applications

Many services and applications are available using the available network infrastructure (Internet). Some examples are given in order to emphasize their potential impact on people with activity limitations.

3.2.5.1. Social Contact

Many social activities are being stimulated by the Internet. It is very easy to establish communication with people and this is having major effects in social contacts. Whether or not these effects will be positive is unpredictable and subject to individual's beliefs and socio-political conviction. However, one of the advantages of the Internet is that it allows people to remain physically anonymous, if they like, and to communicate at the pace at which they are comfortable. Internet socializing can puts on the same footing as everyone else people who have an impairment that makes face-to-face social contact difficult, e.g. people with speech impairments or severe physical impairments.

Some tools that can be used to communicate, cooperate and edit contents to be shared are listed below.

Blogging tools that help people to create blogs, mobile blogs, audio blogs (also known as podcasts) and video blogs (also known as vblogs).

e-Book tools, that are useful for reading as well as creating e-books for PCs or mobile devices.

Graphics and animation tools, that can be used for the production of graphics, animation, pictures and for photo editing.

Video tools. Links to video tools - e.g. video to Flash converter tools, webcam as well as video blogging tools.

Discussion board and forum tools used in asynchronous, text-based discussions.

Instant Messaging, chat and telephony tools for use in live, instant, real-time communications and collaboration.

Social networking (Web2.0) tools to perform social bookmarking, file sharing, start pages and other social networking services and application of use e.g. for e-learners or e-tutors, for both individual or collaborative use.

Wiki tools for editing content in a collaborative way following the wiki model, implemented both as downloadable and hosted services.

3.2.5.2. Education

Another very important set of networked information technology applications is the one connected with technology enhanced learning.

Initially known as ‘computer-assisted learning’ and later e-learning, the study of improving learning processes by the use of technology has evolved into the research domain known as ‘Technology-Enhanced Learning’. Its objective is to encourage the emergence of new learning models that are sustained by the context-aware use of technology and anchored in the practices of users.

Technology-Enhanced Learning (TEL) has a long history. Indeed, since teachers started to use technology such as paper and chalk, they have been seeking to enhance the student’s experience and to make learning easier or more effective. The computer, and then the Internet, have changed many things in the modern world: learners carry clever and expensive mobile computer devices (phones, laptops, PDAs); they can immerse themselves in complex social gaming worlds; the vast libraries of the world are now at their fingertips; and some of these resources can now be constructed by the learners themselves, rather than only passively consumed (Scott and Vanoirbeek, 2007).

The possibility of using such a large amount of devices, resources, media and virtual environments, can be a potential huge benefit for person with some kind of activity limitations, if all these component of the learning process are used in a suitable way.

3.2.5.2.1. Educational Course Management Systems and Virtual Learning Environments

Educational Course Management Systems and Virtual Learning Environments are intended for use by institutions in Higher Education. This makes it easy for teachers to create online courses. As discussed in Wikipedia, Learning Management Systems[57] go far beyond conventional training records management and reporting. The added value for Learning Management Systems is the extensive range of complementary functionality that they offer. Learner self-service (e.g. self-registration on instructor-led training), training workflow (e.g. user notification, manager approval, waitlist management), provision of on-line learning (e.g. Computer-Based Training, Read & Understand), on-line assessment, management of Continuous Professional Education (CPE), collaborative learning (e.g. application sharing, discussion threads), and training resource management (e.g. instructors, facilities, equipment), are some of the additional dimensions of leading Learning Management Systems.

Virtual Learning Environments[58] (VLE) are software systems designed to help teachers by facilitating the management of educational courses for their students, especially by helping teachers and learners with course administration. The systems can often track the learners' progress, which can be monitored by both teachers and learners. While frequently thought of as primarily tools for distance education, they are most often used to supplement the face-to-face classroom.

3.2.5.2.2. Content development and distribution tools

Course and lesson authoring tools are software tools useful for the production of online lessons and courses. They can help to organise documents and e-learning resources into custom courses, and then publish them. Some tools offer real-time collaboration among team members and provide programming-free WYSIWYG environments to create interactive e-learning contents. Assessment capabilities are often included. Some visual authoring tools allow to create interactive components: e.g. they help to visualise knowledge, processes and information in an interactive way.

Simulation and demonstration tools (also known as Screencasting tools) allow the creation of e-learning solutions by means of very realistic simulations, with full interactivity, multiple paths, training layer, trainee evaluation. The result are training experiences where students "learn by doing" in a virtual environment. The obtained e-learning components can be delivered via Internet/Intranet.

Presentation tools can be used for the production of online stand alone and streaming e-learning presentations.

Avatars (Virtual characters) tools can be used for the production of specialist interactive and intelligent content in the form of virtual assistants, mentors etc. Avatar based e-learning solutions can be integrated with a variety of media: Web, CD, kiosk etc. Avatar technologies take sound or text input and generates engaging, captivating and personalised interface consisting in static or interactive avatars.

Testing and quizzing tools are dedicated tools that are useful for the production of online tests, quizzes and games. They allow to create online test/quiz, edit questions and answers, set timers. Using such tools tutors and course managers can create on-line interactive multiple choice questions quickly and

[57] See http://en.wikipedia.org/wiki/Learning_Management_Systems, last visited on 18-Dec-08.
[58] See http://en.wikipedia.org/wiki/Virtual_learning_environment, last visited on 18-Dec-08.

easily. Some software tools enable to design and publish rich-media quizzes typing in questions in the editor and inserting pictures, sounds, videos or flash animations. Assessment reports are automatically generated.

Webcasting and streaming media tools and software allow to create live, interactive web events as well as on demand streamed audio and video. These tools enable customers to rapidly build, manage, and deploy cost-effective rich-media Web sites, both for live events and video-on-demand. Server-side applications can synchronise rich media, scan streaming servers and deliver information to mobile equipments, in order to enable the fruition of interactive learning content by any PC, Mac, set top box or mobile device, anywhere.

E-meeting, conferencing and virtual classroom tools can be used for creating live e-learning sessions and sharing data, audio and video. Moreover they can provide an effective way to manage an interactive class and involve every student, delivering greater customisation options. These tools allow any group, be they teachers and students, to work together in real time in a virtual room with all the facilities that are available in a physical room.

Collaboration tools are used to share bookmarks, files and other resources, and sometimes to hold online discussions. Collaboration environments support shared annotations, i.e. comments, notes, explanations, or other types of external remarks that can be attached to any Web document. When the users get the document, they can also load the annotations attached to it from a selected annotation server or several servers and see what their peer group thinks.

Live e-learning support. A range of tools exist on the market that could be used for providing live e-learning support. These tools deliver the answers when a user has a question. They allow learners to receive instant service and support without leaving the website or interrupting the learning cycle. They provide an easy route to commonly requested information. Powerful inbound and outbound email tools help tutors and teachers to manage unique request.

3.2.5.2.3. Principles for accessibility in online distributed learning

In order to guarantee access to the technology enhanced learning systems by persons using alternate interaction devices and methods, due to their activity limitations as well as their preferences, some principle must be followed in designing and delivering learning applications (IMS, 2002).

Allow for customization based on user preference

When applications make it possible to present information in a versatile way, content becomes more accessible, reaching a wider variety of users. Some examples of customization are: display elements (fonts, cursors, size of text, images and video, screen layout, colours, and backgrounds), and customizable interface features (timing of events, keyboard settings).

Provide equivalent access to auditory and visual content based on user preference

To be fully accessible to deaf or hearing-impaired users, applications should provide equivalent access to all auditory aspects of learning technologies and content, e.g. it is necessary to caption all auditory content or to provide a text transcription of auditory content.

For blind or visually impaired users, applications should provide equivalent access to all visual aspects, e.g.it is necessary to add text descriptions to all static images and to provide audio description tracks for multimedia, describing visual aspects of the content.

Provide compatibility with assistive technologies and complete keyboard access

To assure accessibility, the technology enhanced learning systems, both in their synchronous or asynchronous functioning, must be designed to support the interaction by means of Assistive Technology devices (see § 3.3). In such a way, the access is guaranteed to persons using alternate interaction devices and methods. In particular a complete interaction must be guaranteed using only the keyboard.

Provide context and orientation information

Applications are made more usable when developers provide context and orientation information e.g.: teaching to the users how to navigate, informing of the length of the documents, providing a way to skip standard page headers and navigation links, maintaining a consistent layout between pages, providing alerts/text warning whenever a new browser window will be automatically opened.

Follow Relevant Specifications, Standards, and/or Guidelines

Following relevant specifications, standards and guidelines increases accessibility in two ways. Firstly, some guidelines provide information on how to implement accessibility (e.g. WAI guidelines) within applications and offer useful techniques and suggestions. Then, since accessibility often relies on interoperability between learning applications, software, content, and Assistive Technology, following other relevant industry specifications and standards will also lead to improved accessibility.

3.2.5.3. Positioning, orientation, navigation, and localization

All people sometimes are in need for help because they have lost their way or feel unsafe or have made a mistake in their way-finding effort. However, there are people who feel more at risk than others, not least people with various kinds of activity limitations. Among these, people with visual disabilities and those who suffer from cognitive impairments experience a more challenging approach to this daily living task (Lindströmin, 2006).

A lot of services are starting to appear on the market, mainly to help drivers in navigating, but some of them could be adapted to support navigation of people with activity limitations, by increasing the accuracy of localisation. As an example let us consider the case of GPS. It is evident that a precision of 6 meter is useful for navigations of cars, but not to allow a secure movement in the city to people who cannot see. However, there are technical possibility for improving precision, but this implies additional costs.

3.2.5.3.1. Positioning

As already discussed previously the most widely used and available positioning system is the GPS system. However, a less precise, but not uninteresting method is what’s called 'Cell Global Identity', CGI. This is based on the possibility to register and identify the communication between a telephone and its activated base stations. There is consequently a technical possibility to determine the approximate position of a particular mobile telephone at any given moment. However, the technology is far too imprecise and is not yet adequately established to be of interest in the present context.

The utilization of GPS and CGI results in some form of coordinate references. These are only meaningful if they can be related to reality in the form of an appropriate map reference. Accordingly, access to maps and an appropriate user interface is necessary. This must be available in several alternative designs in order to adapt to the user's special capacities, for example people who cannot see, people with reading and writing difficulties, people with cognitive problems and people with intellectual disabilities.

3.2.5.3.2. Landmarks

A landmark is some kind of identifiable point in the surroundings that people can relate to in order to determine their position. For people with visual impairments, different kinds of acoustic landmarks (sound beacons) have been tested for position determination.

Today, there are various technical possibilities to provide this kind of guidance:

- One is based on Bluetooth technology. When people approach a Bluetooth transmitter carrying an appropriate receiver, pre-recorded information will be read out. Bluetooth transmitters need an energy supply in the form of, for example, an integral battery

- A second possibility is based on what is called RFIDs – Radio Frequency Identification tags.
- WLANs – Wireless Local Area Networks – local, radio-based networks - are a third possibility to send information about what is located in the vicinity to, for example, a mobile telephone or PDA.

All these systems have pros and cons for the user.

- The WLAN concept provides a rather inaccurate position determination if not calibrated at the spot where it is intended to offer positioning capabilities. It is consequently more of an information system than a positioning system
- Bluetooth technology is significantly more precise from a positioning perspective, but it still allows quite a number of meters of deviation without 'losing' the receiver: Bluetooth technology does not support information concerning direction or relative distance between the user and the Bluetooth unit, but merely if a user is within range.
- The RFID circuit is the most accurate, often functioning at very short distances – in the region of a few decimetres.

3.2.5.3.3. Orientation

Some kind of compass is required for orientation. A number of possible technical solutions exists, from magnetic compasses to inertial navigation systems and the GPS system: at present, the GPS system offers the best opportunities available for direction orientation while moving and an integral digital compass function in a handheld unit when stationary.

3.2.5.3.4. Navigation

The simplest form of navigation means that people receive almost continuous backup support – visually or acoustically – in the form of appropriate road descriptions. However, this can also mean information about what is available on the route during the journey, in the form of ancillary information, for example the shops that are available in the vicinity and the range of products that they offer.

3.2.5.4. Maps

Maps are of great importance for navigation for most people. This applies to people with different impairments as well. For people using wheelchairs, for example, it is important to have an overview of the route to be taken and, if possible, to assess any slope, the nature of the route, etc. For people with visual impairments, this is perhaps even more important. In this case, it is necessary to assimilate a mental map of the route to take. This can basically be done in two ways:

- For people with partial sight, maps with good contrast, preferably with different scales for overall and detailed information respectively are necessary. This is relatively simple to do now, since maps are digitally stored. It is also possible to show them in colour and at the desired size on a computer screen and to get a printout on a colour printer.
- For people who are blind, the visual information must be translated into tactile information in the form of raised-line maps. There is no special simple technique to achieve this. It requires processing of the map to be translated and access to special technical equipment.

Most digital land-maps are presently intended for car drivers. They are of very limited use for pedestrians, especially people who are visually impaired. Therefore, maps must be developed that show safe ways for pedestrians, i.e. sidewalks, pathways, stairs etc.

Another method for people with visual impairments is a verbal description where the route is explained in sequence. This information can, for example, be recorded on a pocket memory and retrieved subsequently as the user is moving along.

3.3. AT Today

3.3.1. Introduction

So far the use of Assistive Technology has been the main approach to help people in accessing information and interpersonal communication.

In this section the main Assistive Technology equipment, software and services are briefly described pointing out their main characteristics and their possible evolution due the use of available ICT technology[59].

3.3.2. Definition

Assistive Technology[60] (AT) commonly refers to the technologies (devices or services) used to compensate for functional limitations, to facilitate independent living, to enable elderly and people with activity limitations to realise their full potential. Some of such technologies, even if not purposely designed for people with activity limitations, can be arranged in such a way as to become assistive when needed.

The term Assistive Technology covers any kind of equipment capable to fulfil the aforementioned definition, such as wheelchairs, prosthesis and communicators. The present document will address only a part of the whole AT, that is directly or indirectly related to the Information and Communication Technology (ICT).

3.3.3. AT classification and state of the art

There are several ways of classifying AT, depending on the purpose.

The most widespread classification, the ISO 9999:2007 "Assistive products for persons with disability - Classification and terminology" (TC 173/SC2 - ISO 9999, 2007), is product-oriented. It groups assistive devices into classes, identified by the number before the corresponding definition (each divided into subclasses and these in turn into divisions) based on their main objective (mobility, housekeeping etc):

04 assistive products for personal medical

05 assistive products for training in skills

06 orthoses and prostheses

09 assistive products for personal care and protection

12 assistive products for personal mobility

15 assistive products for housekeeping

18 furnishings and adaptations to homes and other premises

22 assistive products for communication and information

[59] Images in chapter 3.3 AT Today come from the following sources:
1, 2, 3, 7, 8, 13, 14, 15, 16, 17, 18, 19, 20, 23, 24, 28, 29, 30: from http://portale.siva.it/
4, 5, 6, 9, 10, 12, 26 from http://www.rehadat.de /
11, 31 from http://www.dlf.org.uk/
25, 27 from http://www.hmi-basen.dk
21 from http://en.wikipedia.org/wiki/Chorded_keyboard/
22 from http://www.onehandedkeyboard.com/

[60] See http://www.rehabtool.com/at.html, last visited on 18 December 2008

24 assistive products for handling objects and devices

27 assistive products for environmental improvement, tools and machines

30 assistive products for recreation

This classification is widely used all over the world for database and catalogue compilation, so knowing it is a must for anybody interested in the field.

Most of the information on the state of the art on Assistive Technology comes from the European Assistive Technology Information Network EASTIN Association. The Association was founded on December 13, 2006 on the initiative of four Organisations that had been previously partners in the EASTIN project (2004-2005), a market validation initiative partially funded by the European Commission through the eTEN programme. The four founding members are Fondazione Don Carlo Gnocchi Onlus (Italy), Institut der Deutschen Wirtschaft Köln (Germany), Disabled Living Foundation (United Kindgom) and Hjælpemiddelinstituttet (Denmark). Later other partners joined. The main mission of the EASTIN Association is to maintain, develop and exploit the EASTIN network, composed of the EASTIN website and all partner’s databases on Assistive Technology.

For the purpose of the present document, only Assistive Technology systems directly related to ICT are of interest, so that from the aforementioned classes of Technical Aids only “assistive products for communication and information” and “assistive products for handling objects and devices” will be considered.

3.3.4. Assistive Products for Communication and Information

Assistive products for communication and information retrieval are devices used for helping a person to receive, send, produce and/or process information in different forms. Such products include for example devices for seeing, hearing, reading, writing, telephoning, signalling and alarming, and information technology.

3.3.4.1. Assistive products for seeing

This group of AT products deals with the needs of people that have difficulties in seeing, and comprises mainly image-enlarging video systems e.g. devices for displaying an enlarged image of what has been captured by a video camera, to allow a easier view.

The existing technology is based on video cameras that catches the image of the object (newspapers, books, maps etc.) to be enlarged and transmitted to a self stand monitor or to a PC, which displays the enlarged image. The objects lay on a movable tray so that the user can easily explore all parts of it. The image-enlarging video systems can be desktop or portable as shown in the figures.

The use of a PC makes it possible to use the image-enlarging video systems together with usual software tools to deal with documents in electronic form. For example, the use of optical character recognition software could allow a transfer by voice of the text component of the image.

Possible evolutions

The main limitations of the nowadays image-enlarging video systems, are their big dimensions and heavy weight. They are normally desktop equipments. The existing portable devices can show only a small portion of a document, making it difficult to use them except for finding short pieces of information.

Possible solutions for the mentioned problems are rollable displays and projected image system.

Rollable displays are active-matrix displays based on organic electronics. This technology allows to dispose of a large display when in use, which can be rolled up into a small space when not in use[61].

Researchers have demonstrated the ability to project an image which floats in space in front of a person. With special glasses or goggle-based system, only the user can see the image floating there, while some systems project the image directly onto the retina. A pocket controller or gesture recognition can be used to operate the controls that float along the display. Motion sensors can cause the displays to move with the user's head, or stay stationary.(National Council on Disability, 2006)

3.3.4.2. Assistive products for hearing

Devices for amplifying and/or modulating sounds for a person with hearing problems are included, e.g., hearing aids with built-in tinnitus masking and induction coil devices

Possible evolutions

A possible evolution in this field is captioning by means of voice recognition, which in some environments could become a reality in the near future.

By means of voice recognition IBM has developed an ingenious system called SiSi (Say It Sign It) that automatically converts the spoken word into British Sign Language (BSL), using an animated digital character or avatar[62].

Deaf people may soon be able to get help understanding a telephone conversation from an electronic face that they can lip-read as it speaks the words they can't hear. The talking-head telephone, Synface, is a lip-reading support for people with hearing impairments. It has been tested by 49 users with varying degrees of hearing impairments in laboratory and home environments in UK and Sweden. Synface was found to give support to the users, especially in perceiving numbers and addresses and an enjoyable way to communicate. A majority deemed Synface to be a useful product[63].

3.3.4.3. Assistive products for drawing and writing

This subclass comprises devices supporting a person to convey information by producing figures, symbols or text, in suitable forms to be used by persons with some form of difficulties in performing such tasks.

3.3.4.3.1. Braille diaries

Electronically operated portable note-taking devices for Braille, are an example of products belonging to this group; they can take different forms, according with the size of the Braille display (one or more rows of refreshable Braille cells), and the implemented functions

4

[61] See http://www.polymervision.com/, last visited on 2008-12-18
[62] http://www-03.ibm.com/press/us/en/pressrelease/22316.wss, last visited on 2008-12-18
[63] See http://www.synface.com/ , last visited on 2008-12-18

(agenda, address book, etc.).

An example of these equipments is shown in the figure aside: in compact dimensions (174 x 92 x 32 mm) and light weight (450 g), the electronic diary contains a Braille display and a Braille keyboard that allow to perform a number of functions:

- taking notes;
- reading an audio book while walking;
- taking appointments and transfer them to a PC;
- recording sounds and voices;
- storing addresses and phone numbers;
- making calculations;
- sending and receiving SMS;
- listening to music (mp3 player);
- reading audio books in the daisy format;
- make connections to a mobile phone by Bluetooth;
- checking time and temperature;
- etc…

3.3.4.3.2. Word processing software

Even word processing software can be considered an assistive product for writing. As a matter of fact it allows to write, organize and store text in a more easily way than by handwriting: spell check, grammar check and multimedia features can further assist with writing activities. Writing software can provide a structured environment to enhance ability to produce written material. The writing and editing process can be a laborious time-consuming task. Some individuals may experience great difficulty with the physical act of writing. Word processors provide these individuals the opportunity to write without being concerned about making errors during the writing process. Errors are easily corrected and information can be reorganized and edited before printing the final text.

Some word-processing software comprises the possibility of utilizing alternative ways of controlling its use, e.g. by means of scanning selection or virtual keyboard and special output, e.g. Braille or speech synthesis. For example "Talking Word Processor " by Premier Assistive Technology[64] is a word processor software program that has built in text to speech features providing auditory feedback of letter (character), word, sentence or complete paragraphs. Any selected text can also be spoken.

Additionally, assistive software for enabling drawing and/or painting activities with computers is available, specially designed or adapted for persons with motor disabilities.

Possible evolutions

The evolution of PDAs supporting screen readers with good quality synthetic speech output and special interfaces allows blind people to use mainstream products to perform all the tasks pointed out above.

With the enhancement of speech recognition technologies, inputting text via voice is becoming sufficiently affordable to compete with keyboard typing for all users. This can be an effective way to avoid the use of the keyboard for motor disabled persons having a good control over voice production. This possibility is offered as a standard facility e.g. in Microsoft Windows Vista for the English language.

[64] http://www.readingmadeez.com/TalkingWordProcessor.php

3.3.4.4. Assistive products for handling audio, visual and video information

This wide group of AT products includes:

- Devices for storing, processing (e.g. filtering noise or converting analogue to digital information) and displaying audio and visual information: e.g., audio and video equipment, televisions and sound transmission systems.
- Devices for recording and/or playback of sounds: e.g., reel-to-reel and all types of tape recorders, index tone generators, demagnetizers, digital sound recording devices, as Minidiscs, DAT, CD-players and talking book players.
  Persons with reading disabilities can listen to recorded text - textbooks, journals, newspapers - to gain information other than from reading. Audio books are available from many different sources, among them DAISY (see § 3.3.4.8), acronym of Digital Accessible Information System, is a talking book format that enables navigation within a sequential and hierarchical structure consisting of (marked-up) text synchronized with audio. DAISY books have the benefits of regular audio books, but they are superior when it comes to navigating the content and displaying synchronized text;
- Decoders for videotext and text television: devices for translating videotext into artificial speech and/or decoding spoken output to provide video captions
- Induction-loop devices: devices for receiving or transmitting information using electromagnetic waves in induction-loop systems. One of the main use in the AT field is to assist hearing impaired people by transmitting sound from a microphone, television or other source directly to the hearing aid.

Possible Evolutions

As Daisy books store audio in MP3 files, they can be read in any MP3 player or mobile phone, like iPod, Creative Nano, Nokia N95. However, so far there is no mainstream MP3 player on the market that makes full use of the Daisy book structure information. This practically means that a talking book can be read without any problem at all, as long as people want to read it from the beginning to the end at its normal speed. These restrictions in functionality imply less usability for reading textbooks, but may have little or no impact on leisure reading.

Wireless local area network (e.g. Wi-Fi) and Personal area network (e.g. ZigBee) are becoming widely diffused and can be used to substitute the inductive loop as soon as the hearing aids will support them.

3.3.4.5. Assistive products for face-to-face communication

Assistive products for face-to-face communication are devices for helping people to communicate with each other in the same space. The main group of products related to ICT is composed by *dialogue units,* i.e. electronic devices that allow users to perform an Augmentative and Alternative

Communication (AAC), addressing the expressive communication needs of people with speech impairments.

AAC interventions range from no technology (gestures, signs) and low technology (communication board, wallet) to high technology (voice output communication aids). The two most important functions for people using AAC are: saying exactly what they want to say and saying it as fast as possible.

Dialogue devices can be portable and non-portable with recorded and/or synthetic speech output, e.g., alphabet-based and symbolic communicators. Some dialogue devices use special software for producing complete messages for direct communication.

Examples of dialogue units are symbolic communicators: They include single message communicators, e.g. a push button that emit a pre-recorded sentence when pressed, portable multi level communicators, i.e. a box with a grid with symbols that can be pressed one by one or in a sequence to generate pre-recorded messages, and symbolic communicators hosted e.g. by an adapted tablet PC that use synthetic speech output.

Finally, alphabetic communicators allow to digit a message via a standard or adapted keyboard and to show it on a display or to emit it as synthetic speech.

Possible evolutions

Miniaturization can help to make the products for face to face communication more portable and eye movement recognition and gesture recognition can make easier the use of such devices, adapting the way of interacting with them to very basic actions.

The need for a wide display for symbolic communicators could be overtaken by projection or by means of foldable displays that are near to come to the market.

Voice-input voice-output communication aid (VIVOCA) is a prototype system for people with disordered or unintelligible speech, initially conceived for people with dysarthria. The VIVOCA is intended to recognize and interpret an individual's disordered speech and speak out an equivalent message in clear synthesized speech (Hawley et alt., 2007).

3.3.4.6. Assistive products for telephoning (and messaging)

Some examples of Assistive products for telephoning are presented below.

3.3.4.6.1. TDD

A telecommunications device for deaf people (TDD) or text telephone is an electronic device for text communication via a telephone line, used when one or more of the parties have hearing or speech difficulties.

The typical TDD is a device about the size of a small laptop computer with a QWERTY keyboard and a small LEDs display or an LCD screen to display typed text. In addition, TDDs it commonly has a small spool of paper on which text is also printed. The text is transmitted in real time to a compatible device, i.e. one that uses the same communication protocol.

9

3.3.4.6.2. Telephone switchboards

Panels and boards of switches for controlling the operation of a telephone system.

3.3.4.6.3. Software for telecommunication and telematics

This group is made of software for verbal and/or visual communication between computers via the computer network. Examples are: **Instant Messaging** (**IM**), that is a form of real-time communication between two or more persons based on typed text, conveyed via computers connected over a network, and **IP Telephony,** a technology for transmitting voice communications over a network using open-standards based over the Internet Protocol (IP), with the possibility to implement video telephony.

Possible evolutions

The current move to IP communication enables the multimedia concepts to be established easily. It is of great benefit for accessibility. Voice can be used as far as possible. Video can be used for sign language, lip reading and generally for showing objects or feelings in order to ease communication.

Mobile text communication through GSM, like SMS, has gained worldwide popularity, and is often used as an alternative to phone conversation. The methods currently available for text entry on small mobile devices exhibit poor performance in terms of input speed, which present a potential barrier to acceptance and growth. A likely solution is the combination of use of language modelling and careful interaction design and verification, (Johansen and Hansen, 2006). Another difficulty is that communication using SMSs is not real-time, even if, in principle, real time exchange of text information could be made possible. This does not appear of outmost importance for young deaf people, but it is apparently not well accepted by people who presently use text telephones that allow real time communication. However, the use of SMSs would allow text communication with any mobile telephone without mediation by a relay service

Total Conversation

Total Conversation means a telecommunications service enabling voice, text and video communication at the same time and in real time. This service is feasible when telecommunications services are based on Internet Protocol (IP) and the capacity and capability of networks and terminal equipment sufficient to provide satisfactory quality for multimedia services. Standards for multimedia services have been developed in international standardization organizations such as ITU, IETF and 3GPP and are generally available. The IP Multimedia Subsystem (IMS) is envisaged to be the architectural framework to support this service both in fixed and mobile environments.

Total Conversation service based on IP and IMS will probably supersede the current separate voice, text and video services based on circuit switched technologies. However, the transition period is rather long requiring a major upgrade of networks and terminals. It is expected to take 5 – 10 years in mobile environment and 3 – 5 years in the fixed broadband environment. The implementation timetables will significantly vary from country to country and they may go beyond the indicated periods (EICTA, 2007).

Total conversation terminals communicate with each other using any combination of text, voice, images, and video, Therefore, they will allow e.g. sign language and lip reading.

3.3.4.7. Assistive products for alarming, indicating and signalling

Indicators with visual and/or acoustic signals provide visual alerts and/or amplified audible signals in case the doorbell or the telephone rings. They may also alert a carer when the user leaves the wheelchair, the bed or the chair. Other functions include e.g. rain indicators and computer-signal indicators.

Another type of indicator is the light probe, which signals contrast of light via a range of audible tones. Light probes are suitable for detecting obstacles in rooms, open doors, sources of light like lamps, position of the letterhead for typewriter or printer, style of clothing or weather monitoring.

Personal emergency alarm systems are devices either operated by the user or activated automatically in case of personal emergency: e.g., insulin alarms, seizure alarms for people with epilepsy, and fall alarms.

Examples of such products are:

- Alarm systems for monitoring people and calling for assistance via a fixed or cellular telephone;
- Belt-worn fall detectors triggered by change of angle and impact force;
- Auto Dialler Systems;
- Smoke alarm systems for deaf people, with vibrating pad under pillow and/ or strobe light.

Monitoring and positioning systems are devices for monitoring the position of a person: e.g., general positioning systems (GPS) as wandering alarm (see § 3.2.5.3).

Evolutions

Special vibrating materials can be used to make tiny portable devices for alerting people, e.g. wristwatch (e.g. Lynx Tactum[65]) that gives different vibration cadences depending on the occurrence of various events e.g. telephone, door, fire, baby, pager, etc.

3.3.4.8. Assistive products for reading

Some examples of assistive products for reading are listed below.

3.3.4.8.1. Talking reading materials

They include e.g. media for storing written data to be presented it in spoken form.

Multimedia reading materials systems are used to store data for assisting a person by presenting the content in multimedia form: examples are handheld dictionaries and thesauruses that includes a spelling corrector, a grammar guide and educational games. They normally are small table top units comprising a screen, function keys, and a QWERTY keyboard. They can be provided of an output via a speech synthesiser.

11

12

Another class of product are the **talking book readers**, suitable for use both with standard CDs and MP3 CDs. Among them DAISY players have a special relevance. A DAISY book is a digital talking book, designed to allow the reader to move around the text as efficiently and flexibly as a print user. DAISY allows the reader to: make bookmarks, pause books, speed up or slow down, read or ignore footnotes and jump easily from chapter to chapter, heading to heading and page to page. Full exploitation of the structure of books and additional information published in the DAISY format is only possible using a DAISY player or DAISY software on a computer.

Talking colour identifiers are devices that identify the colour of any surface they are placed on; some versions detect multi coloured textures and measure pattern sequences.

Finally, **character-reading machines** are devices for reading and transforming written text into alternative forms of visual, auditory and/or tactile communication They may be based on desk-top scanners that read text from any printed page, including data presented in columns and tables. Then the acquired text is processed by an OCR (Optical Character Recognition) software that output text as synthetic speech or by means of a Braille display, or records it in MP3 format.

[65] http://www.gnresound-ald.com/Lynx/LynxTactum_home.html

Possible evolutions

The technology is available to allow the integration into mainstream PDAs of the aforementioned functionalities, like the possibility of using multimedia reading materials and talking book, playing MP3 audio file as well as producing synthesized speech of good quality.

Another approach can be represented by a software system, based on machine vision, that allows blind or visual impaired people to access the content of a display. An image of the display panel is captured using a digital camera incorporated in a mobile device. The captured image is processed in order to detect the numeric, alpha-numeric and iconographic information. Finally the information is transmitted to the user using text to speech technology. A prototype solution runs on commercial mobile devices, like PDAs, smartphones, etc. (Gutiérrez et alt., 2007).

3.3.4.9. Input devices for computers

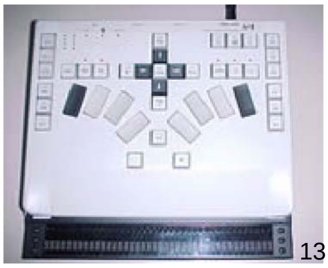
This group includes devices that allow persons with different residual skills to input computer. They include e.g. special or adapted keyboards, mouse, joysticks or alternate input devices. In the following a brief description of the more common functionalities of this group of devices is given.

3.3.4.9.1. Keyboards

The standard keyboard functions can be performed in different ways by means of: Braille keyboards, modified keyboards (simplified, enlarged, reduced, with or without grid), programmable keyboards, scanning keyboards, alternative keyboards (chord, one hand, etc.).

Braille keyboards

Most blind people use a standard QWERTY keyboard when working with a computer. However, for blind people who do not want to learn to use a standard QWERTY keyboard or, for example, when it comes to editing Braille mathematics or music, using a Braille keyboard can be useful.



13

Braille keyboards are completely compatible with the standard keyboard and can be connected to the keyboard port. Some of them can work together with a QWERTY keyboard thanks to an additional switch.

Modified keyboards

Under the term of modified keyboards all those devices that have the same functionalities of a standard QWERTY keyboards, but with different arrangement of keys, or varied dimensions or modified layout to fit to some form of non typical typing ability can be grouped.

14

Simplified keyboards are QWERTY keyboards with a reduced number of keys (only letters, numbers and essential functions) of great dimensions (e.g. 2 x 2 cm), even in different colours. They can be connected to the standard keyboard input and, in some cases, can be used in “parallel” to the normal keyboard, in order to facilitate didactic activities.

Enlarged and reduced keyboards are devices with modified dimensions to fit different typing abilities and residual skills. In some cases the form of keys and layout of the keyboard can be completely different from the standard ones and a sensitive membrane can be used instead of keys.


15


16


17

The use of a standard keyboard can be made easier by means of **grids**, i.e. plastic covers for the keyboard, with holes corresponding to every key, to avoid pressing more keys and/or completely hiding part of the keyboard (e.g. functions key or numeric pad).

Programmable keyboard

Programmable keyboards are tablets where different zones can be assigned programmable functions as: inputting characters, words, or sentence, as well as any simple or complex function. In such a way the keyboard can be adapted to the exact needs of the user related to the task to be performed.


18


19

Scanning keyboard

Scanning keyboards allow users to type in text using only one or two switches: the switches are used to select the desired key by means of different strategies. For example, the keyboard in the picture adopt a group scanning, which allows the choice of the highlighted group of key, then a row per column scanning allows the choice of a key in the group. Scanning keyboards can also be presented on computer screens.


20

Scanning keyboards are a very slow method to input text, but for people with severe motor impairment they may be the only way to interact with a computer and then to communicate with other persons, as well as to control the environment.

Scanning keyboards are often coupled with a prediction system (see § 3.3.4.10) to speed up text input.

Alternative keyboard

A Chord keyboard (or chording keyboard) is a computer input device that allows the user to enter characters or commands by pressing several keys together, like playing a "chord" on a piano. The large number of combinations available from a small number of keys allows text or commands to be entered with one hand.


21


22

One hand keyboards allow people with limited or no use of one hand to continue typing with the other hand in an easy and natural manner.

Both one hand and chord keyboards require long time to learn their functioning at best.

3.3.4.9.2. Mouse-like devices

The mouse is one of the most important input devices for desktop computers, but it requires good hand – eye coordination and fine movement control of the hand. These two characteristics make the mouse a very difficult device to control even for people with mild motor impairments or lack of coordination.

In order to allow the use of the mouse functionalities by motor impaired persons, a number of alternative implementations have been devised that take advantage of different residual skills, as shown by the following examples.

Trackballs

Trackballs of different form and dimensions can facilitate the movement of the cursor on the screen and the clicking actions. Moreover programmable push-buttons allow a more customized use.

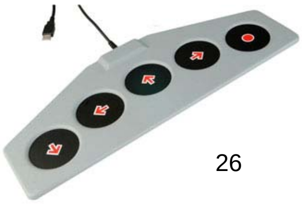
23

24

25

Mouse emulators

Mouse emulators are devices that perform the same functions of a mouse but in a different operative way: e.g. by means of an array of push-buttons, one for each of the four main direction and others for left click, double click etc. Another form allows the user to control the cursor movements using the head and clicking by puffing or sipping a suitable switch. The control of the cursor can be even performed by moving an appropriate device using the mouth. By means of a video camera or sensors the movements of virtually any part of the body can be detected, allowing the control of the mouse functions. Another way of controlling the cursor is detecting the movements of the eyes of the user (eye tracker).



26

Joysticks

Joysticks can be effectively used instead of the mouse for their easier control. The joystick can be connected to the game port of the computer and used by means of suitable software to emulate the mouse functions, or directly connected to the mouse ports, by means of an adapter.

27

3.3.4.9.3. Alternate input devices

Alternate input devices allow input of data to a computer without the use of a keyboard and/or a mouse.

Eye tracker systems

Eye tracker systems detect eyes movements and, together with special software, allow managing, with the movement of the eyes, many functions as email, Internet, telephony, communication through virtual keyboards and speech synthesis.

Speech recognition systems

Speech recognition systems allow input of words or control of the functions to be performed by the computer. They can have a prefixed vocabulary or a vocabulary that can be personalized by the user. If the spoken word is not recognized by the system, it is possible to enter it letter by letter.

Using speech recognition systems, a user is virtually able to completely control the computer and input text by voice. The performances of the systems nowadays on the market are still dependent on the voice of the speaker, even if speaker independent recognition systems for large scale vocabulary are starting to be offered.

Touch screens and touch tablets

The term touch screen denotes all technologies that allow detecting the location of touches within the display area and using it as input. This allows the display to be used as an input device, removing the keyboard and/or the mouse as the primary input device for interacting with the display's content. The touch screen function can be achieved adding a screen over the standard display or can be already embedded in the display itself, as in the case of many PDAs and some laptops.

Moving the finger or a special pen on the screen the mouse functions can be emulated, while the text can be inputted by means of a screen keyboard, a special software that displays the image of a keyboard on the screen and, detecting the position of touches on it, inputs the corresponding character.

The use of touch screens allows the adoption of visual interfaces that change dynamically, in accordance with the task to be completed, so as to optimise the input operation.

Touch tablets are systems with a programmable sensitive surface that allow to perform input functions e.g. mouse emulation, keyboard emulation, and/or input of word, sentences and commands, simply touching a predefined zone of the tablet.

Touch tablets can be easier to operate than touch screens, due to the independence from the display, but they cannot take advantage of the opportunities offered by a display that changes dynamically.

Data glove

The data glove is an input device for virtual reality environments. Various sensor technologies are used to capture physical data such as bending of fingers. Often a motion tracker, such as a magnetic or inertial tracking device, is attached to capture the global position / rotation data of the glove. These movements are then interpreted by the glove software. Gestures can then be categorized into useful information, such as to recognize Sign Language or other symbolic functions[66].

[66] http://en.wikipedia.org/wiki/Data_glove

3.3.4.9.4. Input software

Software that modify the properties of the keyboard

Input software is used to change the properties of the keyboard. Modifications include e.g. the "sticky keys" function that allows a one handed typist to activate shift, control and function keys in combination with other keys.

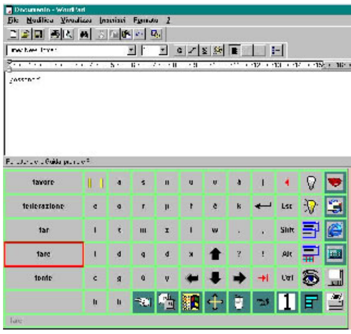
Another common modification is bouncing suppression, i.e. the inhibition of repeatedly pressed keys due to tremors and the control of repetition time when a key is pressed.

Screen keyboards with or without prediction

The layout of a standard or customized keyboard is displayed on the screen and users can interact with it in a number of different ways, according with their preferences and skills. They include mouse click, alternate tracking devices, and automatic scanning.

Some keyboard uses configurable grids of cells that can contain text or images and sometimes voice input can be added.

28



29

In many cases a prediction system is present, i.e. a system that proposes to the user a choice of words that complete the inputted character (word completion). Next word prediction and even multi-word prediction are sometimes available.

In some cases the keyboard can be coupled with a software that manages the functions of the mouse (buttons and click). Placing the cursor on the screen, directly on the function or wished icon, the selection happens immediately.

Possible evolutions

Natural interaction systems like gesture recognition, eye movement recognition and speech recognition will provide an huge number of possible alternatives to the mouse-keyboard for interacting with computers that are going to become smaller and mobile.

Eye tracking

Eye tracking is a general term for techniques for measuring the point of gaze – where one is looking – or for determining eye/head position. Today a number of methods exist for measuring eye movements, and the number of application areas is even larger. The most commonly used eye tracking technique utilizes image processing to detect reflections in a person's eyes.

The eye tracking technique can be used for interaction as unique interaction method (e.g. using screen keyboard for text input) or combined with keyboard, mouse, physical buttons and voice.

Gesture recognition

Gesture Recognition is the attempt, made by computer science, of interpreting human gestures via mathematical algorithms. The term gesture means any bodily motion or state, but commonly originates from face or hands. Using cameras and computer vision algorithms, gesture recognition can originate a far richer connection between machines and humans than Graphical User Interfaces (GUI), which still limits the majority of input to keyboard and mouse.

It enables a hands-free or device-free interaction with a computer, expands the range of possibilities for computer usage, and allows people who can only control limited part of their bodies to interact with a computer in a more satisfactory and effective way the by keyboard and mouse.

Even if examples of gesture recognition are already on the market, a number of problems still exist, like person detection and localization, body pose estimation, motion tracking etc.. The challenge is even greater considering that a recognition system is useless for interacting with a computer if it has a slow reaction-time.

Brain-computer interface

Brain-computer interfaces (BCI) have been identified as a possible extra channel between brain and external environment to transmit information bypassing the spinal and peripheral neuromuscular systems (Wang et al., 2007)

External electrodes in the form of a band or cap are available today as commercial products for elementary direct control from the brain. Research involving electrode arrays, both external and embedded in the brain, have demonstrated the ability to interface directly with the brain to allow rudimentary control of computers, communicators, manipulators, and environmental controls (National Council on Disability, 2006).

It is easy to figure out that the potentiality of such a way of interaction are enormous, but the research is still far from a complete and affordable solution of the related problems.

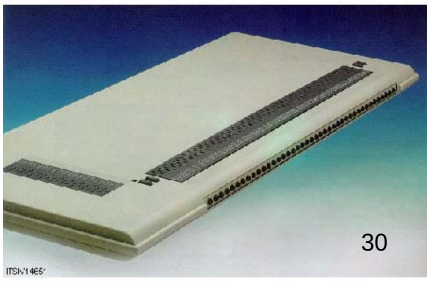
Projected interfaces

Using a projector and camera, companies have created products that can project anything from a keyboard to a full display and control panel onto a tabletop, a wall or any other flat surface. People can then touch the “buttons” in this image. The camera tracks movements, and the buttons or keys operate as if they really existed. One device is pocket sized, projects a keyboard onto the tabletop, and allows users to enter data into their PDA by typing on the image of the keyboard on the tabletop. Other projected interfaces use sound waves (National Council on Disability, 2006).

3.3.4.10. Output devices for computers

3.3.4.10.1. Braille displays

A refreshable Braille display or Braille terminal is an electro-mechanical device for displaying Braille characters, usually by means of raising metal or plastic pins through holes in a flat surface. Blind computer users who cannot use a normal computer monitor may use it to read text output. Braille displays are usually made of 20, 40 or 80 refreshable Braille cells. Some Braille displays are designed to be used with a desktop or portable PC, other are a key component of Braille diaries.



3.3.4.10.2. Braille printers/plotters

A Braille printer, or embosser, is an impact printer that renders text as Braille. Utilizing special translation software, a text document can be embossed, making Braille production much more efficient and cost-effective.

There is a wide range of Braille printers on the market, from small devices for personal use to sophisticated printer for the production of great volumes of press, featuring: automatic pagination of the Braille books, built-in cutters for sheets of variable format, tape conveyer for the collection of the Braille volumes, and embossing on both sides of the sheet with fine regulation of the paper.

Braille plotters are embossers capable to print graphs and drawings as well as Braille characters.

3.3.4.10.3. Alternative output devices

Alternative output devices are equipments for displaying output data, substituting and emulating standard computer output devices in different forms.

Tactile-Vision Sensory Substitution[67]

Tactile displays convert images from a video camera into tactile images to be interfaced with tactile receptors on different areas of the body, such as the chest, brow, fingertip, abdomen, and forehead. The tactile image is produced by a variable number (from some tens to hundreds) of vibrotactile or electrotactile activators, depending on the device. In experiments, blind subjects can learn to detect shapes and to orientate themselves. In the case of simple geometric shapes, it took around 50 trials to achieve 100 percent correct recognition. The identification of objects in different orientations requires several hours of learning.

A system using the tongue as the human-machine interface is also used. The tongue-machine interface is both protected by the closed mouth and the saliva in the mouth provides a good electrolytic environment that ensures good electrode contact. Also, since it is easier to wear an orthodontic retainer holding the stimulation system than an apparatus strapped to other parts of the body, the tongue-machine interface is more popular than other tactile displays.

Tactile-Auditory Sensory Substitution[68]

Presently, there is no tactile-auditory substitution system available, but recent experiments by Schurmann et. al. (2006) show that tactile stimulations can activate the human auditory cortex. Therefore, it seems that vibrotactile stimuli can be used to facilitate hearing in normal and hearing-impaired people. In order to identify the auditory areas activated by touch, Schurmann made experiments stimulating fingers and palms of people with vibration bursts and finger tips with tactile pressure. They found that tactile stimulation of the fingers lead to activation of the auditory belt area, which suggests that there is a relationship between auditory and tactile areas. Therefore, research is being done to investigate the likelihood of tactile-auditory sensory substitution systems.

3.3.4.10.4. Synthetic speech software

Speech synthesis with unlimited vocabulary can be obtained concatenating speech elements like phonemes or diphones or even longer segments. Although speech synthesis has reached an advanced level of maturity, it still suffers from an audible ‘machine accent’, but, since the intelligibility of synthesized speech is comparable to natural speech, synthesized speech is usable in many practical applications. As examples, the screen readers for blind people and communicator for speech impaired people can be mentioned.

A very important parameter which strongly influences overall speech quality is prosody. It is composed of several speech features such as intonation, speed, rhythm, pauses, intensity and is connected to other features such as voice quality (breathy, modal, c r e a k y, etc). All these features

[67] http://en.wikipedia.org/wiki/Sensory_substitution
[68] http://en.wikipedia.org/wiki/Sensory_substitution

together, as a whole multidimensional set, carry the so-called supra-segmental information to the utterance and can make speech human-like and more intelligible.

3.3.4.10.5. Screen readers

A screen reader is a software application that attempts to identify and recognize what is being displayed on the screen. Information on the screen is then conveyed to the user with synthetic speech, sound icons, or a Braille output. Screen readers are useful to people who are blind, visually impaired, or learning disabled, often in combination with other assistive technologies such as screen magnifiers.

The screen readers offer a variety of functions allowing a blind person to fully explore what is displayed on the screen of a PC as long as the content is text or suitably augmented media, e.g. images with an alternate text linked to them.

Some screen readers offer a scripting language to customize their behaviour.

On the market there are already available screen readers for mobile devices (PDAs and mobile phones) with synthesized speech out of good quality. These systems assure the possibility of performing a number of tasks on the move (e.g. taking notes, sending and receiving e-mail, browsing the Web) to blind and visually impaired persons. Some limitation still occurs to the interactions due the lack of predisposition of several mobile devices for alternate interaction methods.

3.3.4.10.6. Screen magnifier

A screen magnifier is a software application able to present the computer graphical output contents enlarged on the screen. It is a type of Assistive Technology suitable for visually impaired people with some residual vision. The simplest way of magnification is to present on the entire screen an enlarged portion of the original screen content, e.g. the zone where the focus is, following the movement of the pointer or cursor. The tracking must not be jerky or flickering in order not to disturb the user. Also, the software must be able to understand that is some cases, the pointer is not the focus of interest: for example, if the user presses a keyboard shortcut that opens a menu, the magnified portion should jump to that menu. Pop-up windows and changes in system status can also trigger this rapid shifting.

The commercial available screen magnifiers have several customizable features, like the magnification scale, the possibility of using windows and not the entire screen for enlargement, the shape of the enlargement window (e. g. a small and long window useful to enlarge few row of a typed text), the type of movement of the enlarged portion (e.g. continuous with the cursor movement, or changing when the cursor exits from the enlarged zone). Some products are coupled with a screen reader, to facilitate reading documents, as well as complementing visual interaction.

Possible evolutions

Multi-Modal Communication.

There is a rapid diversification taking place in the ways people can communicate. Video conferencing allows simultaneous text, visual, and voice communications. Chat and other text technologies are adding voice and video capabilities. In addition, the technology to cross-translate between modalities is maturing. The ability to have individuals talking on one end and reading on the other is already available using human agents in the network (see relay services). In the future, the ability to translate between sensory modalities may become common for all users (National Council on Disability, 2006).

One of the potentials of multimodality is to adapt the type of interaction to the abilities and preferences of the user, e.g allowing a voice interaction if the user is blind or cannot look at the display, or providing a gesture interaction when the user is not able or prefer not to speak.

Tactile interfaces

Nowadays, most haptic applications for blind people use sounds as verbal commands for navigation purposes or for providing complementary information about events or the presence of people in the environment. Recent advances in automatic sound generation algorithms enable the creation of sound as a direct result of the interaction of the user with the environment. Using these algorithms, sound is generated in real-time and is equal to the real one that a user would listen in the real world. There is no need to use previously recorded sounds. This fact improves significantly the interactivity of these virtual applications. However, it is not clear in advance how the brain perceives and processes the same information of an event in a virtual environment coming from two different sensorial modalities (haptic and sound) (Diaz et alt., 2007).

3.3.4.11. Assistive Products for Handling Objects and Devices

3.3.4.11.1. Assistive products for operating and/or controlling devices

Turning a switch on/off is a simple operation that must be performed to control electrical, electronic and electromechanical devices. A great number of switches that can be operated virtually with every residual skill exists.

As examples, switches that can be operated by the exerting a more or less intense pressure with every part of the body can be mentioned: a wide range of alternatives, from very sensitive switches for persons with reduced force to very strong ones suitable for persons unable to control their force, exist. Moreover, switches that can be operated sipping or puffing, or by the contraction of a muscle, or by means of the eyelashes movements, etc. can be mentioned.

Switches can be integrated into switchboards, to control a certain number of devices/functions.

Timer switches can control electrical devices that are programmed at set intervals of time.

3.3.4.12. Assistive products for controlling from a distance

3.3.4.12.1. Remote-control

Remote control devices are normally portable environmental control units enabling control of a range of household equipment including: TVs, lights, telephones, doors, curtains and alarms. They can be based on: picture based menu and icons with tactile keys; LCD providing confirmation of selection and access to sub menus; single or dual switch input with scanning; programming for phone numbers and selected functions; infrared control and radio control up to 100m; radio operation of community alarms; optional voice announcement of functions via speaker or headphones.

3.3.5. Other Assistive Technologies and applications

3.3.5.1. Products with Integrated ICT technology

Communication and information technology is also used in systems classified in other areas of the ISO classification, e.g. wheelchair controls, furnishings which are connected and support independent living, etc. This pervasive migration of ICT technologies toward daily living objects is in line with the Ambient Intelligence development scenarios, where the technology is supposed to disappear in objects and in the surrounding environment, allowing every person to benefit of its functionalities.

As an example, there are presently many severely mobility impaired people who need a variety of assistive devices (e.g. a powered wheelchair, environmental control devices, communication aids and robotic manipulators), to gain a minimum level of independence. Assistive technology has made such devices available. The main problem is the variety of these assistive devices that makes their interconnection on a basic wheelchair platform difficult, time-consuming and costly.

3.3.5.2. Assistive Technology for Cognition (ATC)

It is commonly accepted that technology can effectively facilitate participation of persons with cognitive disabilities in many activities that would otherwise not be possible. Technological interventions have been developed to assist with tasks requiring cognitive skills as diverse as complex attention, prospective memory, self-monitoring for the performance of specific desirable behaviours, inhibition of undesirable behaviours, sequential processing, and understanding of social cues.

These assistive technologies can improve functioning in a number of ways. One approach has been to provide cues, reminders and sequential guidance when task completion would otherwise not be possible—in effect, serving as a "supervisory attendant" or "aide" for the person. A related approach has been to develop interventions that restructure task demands so that residual abilities can be used in place of those that are impaired. More recently, researchers have been exploring the applications of artificial intelligence, virtual reality, and other advanced technologies to ATC systems, so that a broader range of complex tasks can be addressed and the likelihood of generalisation enhanced (Lo Presti, 2004).

3.3.5.2.1. Compensation technologies for memory

Technological interventions can provide compensatory support for a number of executive function impairments and the complex memory deficits often associated with the integrity of executive functions (Lo Presti, 2004). Related memory skills include "prospective memory", that is, remembering tasks that need to be performed and carrying out these tasks at the appropriate time (Ellis, 1996).

Prospective memory aids consist e.g. of alarm systems that provide an audible cue, combined with a written list, so that whenever the watch alarm sounds the person refers to the list for information: it is useful to have a single, easily portable device that provides both an external cue and relevant information. Prospective memory aids are most effective when they can be customized for a specific user and his or her desired Activities of Daily Living (ADLs) (Chute & Bliss, 1988).

Some prospective memory aids are designed for and marketed to the mainstream population, rather than specifically for people with cognitive disabilities. Other devices have been designed specifically for individuals with cognitive disabilities. They provide more support for people who would have difficulty independently entering their schedules into more complex devices and are designed with physical and sensory limitations in mind (Lo Presti, 2004).

The Memory Aiding Prompting System (MAPS) (Carmien 2004) incorporating a PDA with a docking system, wireless communication, and data logging, allows a caregiver to program the user's schedule on a computer, which downloads the schedule to the user's PDA. The wireless communication allows the user or the system to contact a caregiver when problems that the system cannot automatically handle arise. Data logging facilitates evaluation of the effectiveness and appropriateness of the system.

3.3.5.2.2. Compensation technologies for planning and problem solving

Some ATC interventions seek to provide support with planning and problem solving as well as prospective memory.

As an example a device can be cited where the user manually enters appointments. The device, in conjunction with a library of scripts, generates the best plan to complete all the required steps, and assists with plan execution by using visual and audible cues. The user provides input to the device when a step has been completed, or if more time is required to complete the step (Levinson, 1997).

Some research has shown that a system which combines automatic presentation of such pictorial instructions with auditory or tactile cues can improve performance (Lancioni et al., 2000).

3.3.5.2.3. Context-aware cognitive orthoses

Many ATC interventions described thus far require input from the user. However, people with a cognitive disability may not remember what step they had just been asked to perform and/or the need to indicate that the step had been completed (Vanderheiden, 1998b). Even for those people capable of providing this input, the additional requirement increases the cognitive load, and can result in the user becoming further frustrated and agitated. In addition, users who lack initiation and planning skills may not be able to actively retrieve the messages or information stored in these devices (Friedman et al., 1991). This could be remedied if a device were able to recognise the user context; that is, their physical and social environment.

3.3.5.2.4. Compensation technology for sensory processing

Cognitive disabilities often result in an inability of the brain to properly process and integrate sensory information (Kielhofner, 1997). This can lead to deficits in a number of skill areas, including: visual–spatial processing, auditory processing, sensory–motor processing, language processing, and understanding of social cues.

Populations affected include people with learning disabilities, traumatic brain injuries, and autism disorders. By allowing information to be presented in different ways, computers can provide people with the flexibility to utilise their strengths and accommodate information-processing deficits. For example, computers can translate information from printed text to audible speech, or from audible alerts to tactile (e.g., vibrating) alarms. Adjustments to the interface between human and computer, made with attention to a particular client’s needs and strengths, can greatly improve the performance of desired tasks (Gregor & Newell, 2000).

3.3.5.2.5. Technologies for social and behavioural issues.

Sensory processing impairments can also lead to social and behavioural difficulties.

If an individual is easily overwhelmed by environmental stimuli, he or she may have difficulties with concentration and social engagement (Strickland et al., 1996). Difficulties in processing visual information about faces, or auditory information about a person’s tone of voice, can also impair a person’s ability to recognise social cues.

One application of ATC is to modify speech so that individuals can more easily comprehend it and its auditory cues. First, the speech is e.g. prolonged, allowing more time for auditory processing. Second, sounds that are marked by high frequency or rapid transitions are made louder, so that they will be easier to comprehend (Nagarajan et al., 1998).

Technology is also being applied to allow people with dementia to communicate by augmenting their short-term memory capabilities. A conversation support system is being developed based on touch screen access to multimedia material. The system is designed in such a way as to help users to be able to use it easily, and to be able again to enjoy holding conversations with relatives, friends, and carers. The conversations are based on reminiscence about the past, since long-term memories can remain relatively intact with dementia, even where short-term memory is ineffective (Astell et al., 2002).

3.3.5.2.6. Avatar for GUIs for Alzheimer users

One of the problems when using computers for Assisted Living for people with Alzheimer's disease is how to direct the user's attention on the content presented via any kind of user interface. Photo realistic "known" talking heads (avatars) can be a possibility to make GUIs more attractive for people with dementia. In some cases they can be used to raise the users' awareness towards the system. In some experiments, users showed emotions towards the avatars, from "sending a kiss to the daughter" to starting to argue with the avatar shown. (Morandell et alt., 2007)

3.3.5.3. Examples of telecommunication services and applications

As an example of services already deployed, the relay services are briefly described. Then some applications based on broadband communication, that are possible and already tested, will be reported.

3.3.5.3.1. Relay services

The Telecommunications Relay Service, also known as TRS, Relay Service, or IP-Relay, is an operator service that allows people who are deaf, hard–of–hearing, speech disabled, and deafblind to place calls to standard telephone users via TDD, TTY, personal computers or other assistive telephone devices.

The text telephone enables customers who cannot use the telephone, because of, for instance, deafness or a speech impairment, to talk to each other using a keyboard and display unit. It enables them to talk to other users of text telephones. A relay service is a real-time manned system which translates in both directions from text to voice and voice to text. The customers call the relay service, identify themselves and inform the operator of the number they wish to call. The operator calls this number and when the call is connected, translation can take place in either direction via the operator. The following is a list of some additional features of relay services.

Voice-Through: many deaf people have clear enunciation, particularly if their deafness occurs later in life, and consequently many relay services offer voice-through facilities. This system saves time and increases the sense of "realism" of the call. This possibility should be made available in every European country.

One room conversations: the applications of the relay service for the target group are extended from the usual telephone conversations to conversations in the same room. The one room application involves personal conversations where the conversation partners have a face-to-face talk. This allows hearing impaired persons to have access to and to participate in speech-based conversations, and offers more social inclusion aspects.

Slow text input system: one of the difficulties of the current relay service is the low conversion speed from speech into text.

Video relay services: relay services for video telephony have been available since 1997. They are primarily used for relaying telephone calls between a deaf person using sign language and a talking person.

Relay services over IP: as the communication (voice and video) over IP is becoming popular and widespread, voice and video relay services can be more effectively merged and delivered by means of the common network infrastructure. Collaborating interpreter centres or companies can now connect their studios to the service and supply interpreter services. The incoming calls can be distributed through an Automatic Call Distribution (ACD) mechanism. This gives the relay service flexibility and ability to grow. The dependency on certain interpreter centres and geography is also minimized.

Evolutions

One of the most interesting evolutions is the implementation of relay services without operator.

These services are supposed to be based on voice recognition technology for replacing the human operator with a voice to text equipment. This system must recognize speech and transform it into text. The vice versa transformation can be obtained with a speech synthesizer.

Some problems for developing an automatic system still exist: (i) the system must be able to handle any message or conversation because the relay service cannot be based on a restricted vocabulary; (ii) in a natural conversation many syntactical mistakes, elisions etc occur; (iii) people talk with “spontaneous and continuous speech”; (iv) in principle the system has to deal with any person, and has to be a user-independent recognizer; (v) any telephone line can be switched to the speech recognition system. This means that the system must have a high robustness, because telephone channel characteristics might be very different.

Problems with speech technology are not yet completely solved for this application.

3G relay services

The use of 3G is rather extensive among people who are deaf. (According to the Swedish National Association for the deaf an estimated 4 000 to 6 000 people who are deaf use a 3G telephone). These data lead to develop methodology and technology for distance interpreting and mediation of mobile video calls (3G), also in connection to the new IP platform. The person that require the interpretation service, while moving, can issue a call by means of her/his 3G phone to the service centre, that route the video call via the IP network. Then the call is managed by the same platform and in the same manner as any other call to the service.

3.3.5.4. Broadband services

With the advancements in technology and the diffusion of mobile devices and broadband, it has become possible to send and receive large quantities of information via computer networks in a variety of contexts. The opportunities for communication have broadened to include e-mail, chat and video communications in real time and, thus, it has become easier to choose the means of communication that best suits each individual (Roe, 2006, section 2.3.1). The bottom line is that technological developments have made it possible to implement a series of new services for people with disabilities.

For example, the National Post and Telecom Agency (Post-och telestyrelsen PTS), in Sweden, has set up trials for a number of new services intended to help people with different form of disabilities:

- Service centre for people who are blind or deafblind: this service was developed to enable communication between blind or deafblind person and a manned service centre, with the aid of a computer-based terminal with cameras and broadband connection. The conversation can be conducted through pictures, text and speech. This service can in principle help blind or deafblind people to read food packaging, or to try to find something they have lost and is actually lying right under their nose.
- Distance education for people with mild aphasia. This service exploits the possibility of combining speech and pictures in distance learning, to help people mild aphasia to communicate as effectively as possible. Distance courses, offered using the best possible broadband technology available, allow students to continue living at home while they are studying.
- Digital distribution of talking books to university students. The service provides access to talking books through broadband networks for University students with reading disability (people with visual impairment, dyslexia and restricted mobility). Students can use the service to get their course literature via digital distribution.
- Broadband for people with intellectual impairment. This service offers the possibility for people with intellectual impairment to communicate with each other at a distance with two-way video communications with high audio and video quality. Using a computer with a broadband connection provides opportunities for enhanced participation and independence.

- Distance education in sign language. This service offers flexible courses allowing sign language interaction between course leaders and participants. Communication takes place by video over the Internet, either as direct communication or through the participants downloading video files or sending video messages.
- Winning Communication – distance guidance. This service uses video communication in regular work at employment offices, to allow jobseekers with disability to contact specialists at the employment offices and thereby enhance opportunities of finding work.
- Mobile video communications for people who are deaf. This service offers the opportunity to deaf people to use video calls to communicate with people using sign language. A deaf person can contact a sign language interpreter through a 3G telephone and communicate directly with a hearing person. This may be useful, for instance, for distance interpretation, when visiting the bank or during a spontaneous meeting.

The latter service was developed within a more general project by the PTS, which has developed a platform to offer a call centre solution in which collaborating interpreter centres or companies can connect their studios and supply interpreter services for deaf people. The incoming calls are distributed through an automatic call distribution (ACD) mechanism, to offer distance interpretation and relay of mobile video calls, allowing people living in all geographical areas to benefit from services given by interpreter centres.

Also, there are numerous examples of systems to help users with memory or cognitive problems structure their everyday life by giving a reminder about things that must be done (take medicine, get up, do shopping, etc.), or to track and find the position of a person.

Mobile telephony operators in Europe commonly offer home surveillance and security services through the use of a video camera that monitors the user's house and lets the user view the video live, using the UMTS connection.

3.4. From assistive technology to design for all – a historical perspective

Let us now concentrate on an example of migration from Assistive Technology to design for all, based on projects funded by European Commission Programmes. They have span across 15 years, and they have pursued an evolutionary path, initially adopting reactive, and subsequently advocating proactive strategies to accessibility.

3.4.1. Specifications and tests of specifications

What is important to notice in relation to these projects is the progressive shift towards more generic solutions to accessibility. In fact with the exception of early exploratory studies, which did not have a research and development dimension, all remaining projects embodied both a reactive research and development component as well as a focus on proactive strategies and methods. The latter were initially oriented towards the formulation of principles, while later on emphasis was placed on the demonstration of technical feasibility.

As an exploratory activity, the IPSNI project (Integration of People with Special Needs in the Broadband Communication Network) investigated the possibilities offered by the multimedia communication network environment, and in particular B-ISDN (Broadband Integrated Services Digital Network), for the benefit of people with activity limitations. In order to enable their accessibility to the emerging telecommunications technology, the IPSNI project considered essential that the designers and/or providers of the services and terminal equipment take explicitly into account, at a very early stage of the design, their interaction requirements. Several barriers were identified which prevent people with activity limitations from having access to information available through the network. The identified barriers are related to accessibility of the terminal, accessibility of the anticipated services, and the perception of the service information[69].

In order to cope with these difficulties, different types of solutions have been proposed, which address the specific user abilities and requirements, at three different levels:

- Adaptations within the user-to-terminal and the user-to-service interface, through the integration of additional input/output devices and the provision of appropriate interaction techniques, taking into account the abilities and requirements of the specific user group;
- Service adaptations through the augmentation of the services with additional components capable of providing redundant or transduced information;
- Introduction of special services, only in those cases where the application of the two previously mentioned types of adaptation are not possible or effective.

Early development efforts aimed to provide tools for ease of adaptation of a hierarchical interaction model to alternative modalities. The INTERACT user interface design and construction tool was developed in the context of IPSNI-II (Access to B-ISDN Services and Application by People with Special Needs) and is representative of this effort. One of the shortcomings of this approach was its focus on translating a graphical user interface into an alternative non-visual manifestation. However, for blind users who are not familiar with graphical environments, it was difficult to grasp the inherently visual concepts (e.g., the pop-up menu). Such an observation, which was also supported by concurrent developments in the context of the GUIB project (Textual and Graphical User Interfaces for Blind People), led to the realisation that adaptations cannot provide an effective approach for a generic solution to the accessibility problems of blind users.

The IPSNI-II project built on the results of the IPSNI project, and demonstrated the technical feasibility of providing access to people with activity limitations to multimedia services running over a broadband network. Adaptations of terminals and services were implemented and evaluated. In particular, two pairs of multimedia terminals (one UNIX/X-Windows based and one PC/MS-Windows based) were adapted according to the needs of the selected user groups. Special emphasis was placed on the adaptation of the user interfaces, and for this purpose, a user interface design and construction tool was designed, named INTERACT (Stephanidis and Mitsopoulos, 1995), which takes into account the interaction requirements of impaired users. INTERACT builds on the notion of separating an interactive system in two functional components, namely the application functional core and the user interface component, thus allowing the provision of multiple user interfaces to the same application functionality.

The IPSNI-II project allowed an in-depth analysis of services and applications for the broadband telecommunications environment from the point of view of usability by people with activity limitations, leading to the identification and testing of necessary adaptations and/or special solutions. This work led to the conclusion that if emerging services, applications and terminals were designed considering usability requirements of users with activity limitations, many of their access problems would be automatically reduced with a negligible expense. One of the conclusions was that, as a minimum, sufficient modularity and flexibility should be the basis of product implementation, in order to allow easy adaptability to the needs, capabilities and requirements of an increasing number of users.

The TIDE-GUIB and TIDE-GUIB-II projects aimed to identify and provide the technological means to ensure continued access by blind users to the same computer-based interactive applications used by sighted users. The short-term goal of the GUIB project was to improve adaptation methodologies of existing GUIs. Specific developments were carried out through the implementation of appropriate demonstrators enabling access to MS-WINDOWS™ (PCs) and to interactive applications built on top

69 The IPSNI deliverables are available in the EDeAN Ariadne resource centre.

of the X WINDOW SYSTEM (UNIX^{TM} based workstations). The GUIB approach to interface adaptation for blind users was based on a transformation of the desk-top metaphor to a non-visual version combining Braille, speech and non-speech audio. Access to basic graphical interaction objects (e.g., windows, menus, buttons), utilisation of the most important interaction methods, and extraction of internal information from the graphical environment were investigated.

Input operations (e.g., exploration/selection of menu options, etc.) can be performed either by means of standard devices (keyboard or mouse) or through special devices (i.e., mouse substitutes, touch pad and routing keys of Braille device). An important feature of the method is that the whole graphical screen is reproduced in a text-based form and simultaneously presented on a monochrome screen which can be explored by blind users by means of Braille and/or speech output. Additionally, sounds help navigation and provide spatial relationships between graphical objects. It is important to note that the text-based reproduction facilitates cooperation with sighted colleagues.

The GUIB project also investigated a variety of issues related to user interaction in a graphical environment, particularly for users who cannot see. For example, the project investigated different input methods that can be used instead of the mouse. It also studied the problem of how blind users can efficiently locate the cursor on the screen, and examined issues related to combining spatially localised sounds (both speech and non-speech) and tactile information in order to present available information. Finally, the project addressed the design and implementation of real-world metaphors in a non-visual form and the development of an optimal method to present graphical information from within applications.

3.4.2. Preliminary proactive approaches

A first step toward the development of tools aimed to the implementation of 'user interfaces for all' was carried out in the already mentioned GUIB and GUIB-II projects. The goal of these efforts was the development of innovative user interface software technology aiming to guarantee access to future computer-based interactive applications by blind users. In particular, these projects conceived, designed and implemented a User Interface Management System as a tool for the efficient and modular development of user interfaces that are concurrently accessible by both blind and sighted users.

The concept of Dual User Interfaces (Savidis and Stephanidis, 1995a) has been proposed and defined as an appropriate basis for "integrating" users who can or cannot see in the same working environment. A Dual User Interface is characterised by the following properties:

(i) it is concurrently accessible by blind and sighted users;

(ii) the visual and non-visual metaphors of interaction meet the specific needs of sighted and blind users respectively (they may differ, if required);

(iii) the visual and non-visual syntactic and lexical structure meet the specific needs of sighted and blind users respectively (they may differ, if required);

(iv) at any point in time, the same internal (semantic) functionality is made accessible to both user groups through the corresponding visual and non-visual "faces" of the Dual User Interface;

(v) at any point in time, the same semantic information is made accessible through the visual and non-visual "faces" of the Dual User Interface respectively.

The HOMER User Interface Management System (Savidis and Stephanidis, 1995a; Savidis and Stephanidis, 1998) has been developed to facilitate the design and implementation of dual interfaces. HOMER is based on a 4th generation user interface specification language (the HOMER language), which supports:

(i) abstraction of interaction objects, i.e., representation of objects based on their abstract interaction roles and syntactic / constructional features, decoupled from physical presentation aspects;

(ii) concurrent management of at least two toolkits, so that any modifications effected on the interface by the user through the objects of one toolkit are concurrently depicted in the objects of the second toolkit;

(iii) metapolymorphic capability for abstract objects, i.e., abstract objects can be mapped to more than one toolkits, or to more than one object classes within a specific toolkit;

(iv) unified object hierarchies supporting different physical hierarchies, so that alternative mappings of –portions of- the unified hierarchy to -portions of- physical hierarchies are possible;

(v) ability to integrate different toolkits;

(vi) object-based and event-based model support for dialogue implementation, i.e., the dialogue model can be defined either on the basis of the individual objects that participate in it, or on the basis of interaction events that originate from those objects;

(vii) declarative asynchronous control models (e.g., preconditions, monitors, constraints), as opposed to syntax-oriented control models (e.g., task notations, action grammars), or alternative control techniques (e.g., event-based models and state-based methods); the rationale behind the adoption of declarative control models concerns the desired independence from specific syntactic models, which allows for differing models, supported by different toolkits, to be supported.

A non-visual toolkit to support non-visual interface development, called COMONKIT (Savidis and Stephanidis, 1995b; Savidis and Stephanidis, 1998b), was developed and integrated within the HOMER UIMS. The COMONKIT library has been developed on the basis of a purposefully designed version of the Rooms metaphor, an interaction metaphor based on the physical environment of a room, and whose interaction objects are floor, ceiling, front wall, back wall, etc.. The COMMONKIT library provides efficient navigation facilities, through speech / Braille output and keyboard input. Two different non-visual realisations of the Rooms metaphor have been assembled:

(i) a non-spatial realisation, supporting Braille, speech and non-speech audio output with keyboard input;

(ii) a direct-manipulation spatial realisation, combining 3D audio (speech and non-speech), 3D pointing via a glove and hand gestures, keyword speech recognition and keyboard input (Savidis et al., 1996). In both realisations, special sound effects accompany particular user actions such as selecting doors (e.g., "opening door" sound), selecting the lift (e.g., "lift" sound), pressing a Button or a Switch object, etc..

The Athena widget set (for visual windowing interactions) and the COMONKIT toolkit (for non-visual Rooms dialogues) have been imported within the HOMER UIMS, maintaining the original (i.e., native) "look & feel" of their respective toolkit. The toolkit integration mechanism of the HOMER language has been practically demonstrated by importing together the Athena toolkit, (complying to the desktop windowing metaphor), and the COMONKIT library (realising the Rooms metaphor).

The HOMER UIMS has been utilised for building various dual interactive applications such as: a payroll management system, a personal organiser and an electronic book with extensive graphical illustrations and descriptions (Savidis and Stephanidis, 1998).

The concept of User Interfaces for all (Stephanidis, 1995a) has been proposed, following the concept of design for all, as the vehicle to efficiently and effectively address the numerous and diverse accessibility problems. The underlying principle is to ensure accessibility at design time and to meet the individual needs, abilities and preferences of the user population at large, including disabled and elderly people.

3.4.3. A complete approach to User Interfaces for All

The ACCESS project (Development Platform for Unified ACCESS to Enabling Platforms) aimed to develop new technological solutions for supporting the concept of User Interfaces for all, i.e., universal accessibility of computer based applications, by facilitating the development of user interfaces automatically adaptable to individual user abilities, skills, requirements, and preferences. The project approached the problem at two levels:

(i) the development of appropriate methodologies and tools for the design and implementation of accessible and usable User Interfaces;

(ii) the validation of the approach through the design and implementation of demonstrator applications in two application domains, namely interpersonal communication aids for speech-motor and language-cognitive impaired users, and hypermedia systems for blind users. The ACCESS approach enables designers to deal with problems of rehabilitation and access to technology in a consistent, systematic and unified manner.

The ACCESS project has proposed the concept of Unified User Interface development (U2ID), with the objective of supporting platform independence and target user-profile independence, i.e., possibility of implementation in different platforms and adaptability to the requirements of individual users (Stephanidis, Savidis and Akoumianakis, 1997; Savidis, et al., 1997; Akoumianakis, Savidis and Stephanidis, 1999). Unified user interface development provides a vehicle for designing and implementing interfaces complying with the requirements of accessibility and high quality interaction.

A unified user interface comprises a single (unified) interface specification, targeted to potentially all user categories. In practice, a unified user interface is defined as a hierarchical construction in which intermediate nodes represent abstract design patterns de-coupled from the specific characteristics of the target user group and the underlying interface development toolkit, while the leafs depict concrete physical instantiations of the abstract design pattern. The unified user interface development method comprises design- and implementation oriented techniques for accomplishing specific objectives. The design-oriented techniques (unified user interface design) aim towards the development of rationalised design spaces, while the implementation-oriented techniques (unified user interface implementation) provide a specifications-based framework towards constructing interactive components and generating the run-time environment for a unified interface.

To achieve the above, unified user interface design aims at:

(i) initially identifying and enumerating possible design alternatives, suitable for different users and contexts of use, using techniques for analytical design (such as design scenarios, envisioning and ethnographic methods);

(ii) identifying abstractions and fusing alternatives into abstract design patterns (i.e., abstract interface components that are de-coupled from platform-, modality-, or metaphor- specific attributes);

(iii) rationalising the design space by means of assigning criteria to alternatives and developing the relevant argumentation, so as to enable a context-sensitive mapping of an abstract design pattern onto a specific concrete instance.

The result of the design process is a unified user interface specification. Such a specification can be built using a dedicated, high-level programming language and results in a single implemented artefact which can instantiate alternative patterns of behaviour, either at the physical, the syntactic, or even the semantic level of interaction. The unified implementation, which is produced by processing the interface specification, undertakes the mapping of abstract interaction patterns and elements to their concrete / physical counterparts.

In particular, the process of unified user interface implementation involves two distinctive steps, namely platform integration and interface specification (Akoumianakis, Savidis and Stephanidis 1999). Platform integration refers to the process of building a unifying programming layer on top of the interface toolkits which comprise the physical interaction resources (i.e., they provide the concrete means – in the form of buttons, menus, etc., through which physical interaction actually takes place). This unifying layer is necessary for transforming a unified user interface to a physical interface instance, given a target user, platform and usage context. Interface specification, on the other hand, entails the use of appropriate tools for:

(i) the construction of a unified user interface as a composition of abstractions at different levels of interaction;

(ii) the manipulation and management of the physical resources;

(iii) the establishment of the relationships between the involved abstractions and the available physical resources (Savidis et al., 1997). The detailed architectural abstractions of a supporting tool environment that realizes these steps have been presented in (Stephanidis, Savidis and Akoumianakis, 1997; Akoumianakis, Savidis and Stephanidis, 1999).

In order to efficiently support the implementation of unified User Interfaces, a development environment has been built, which includes a high-level language for User Interface specification, called G-DISPEC (Savidis and Stephanidis, 1997b), and a tool called I-GET (Savidis and Stephanidis, 1997b; Stephanidis, Savidis and Akoumianakis, 1997) that automatically generates the implementation from such high-level specifications. The G-DISPEC language and the I-GET tool constitute a novel User Interface Management System for Unified User Interface development. Additionally, another tool has been developed, called PIM (Savidis, Stephanidis and Akoumianakis, 1997), which enables the generation of platform independent toolkits (i.e., programming libraries) for unified interface implementation. Two toolkits have been generated as examples of the viability of the approach: an augmented version of the Windows interaction object library, including scanning techniques (Savidis, Vernardos and Stephanidis, 1997); and a toolkit for non-visual interaction (Savidis, Stergiou and Stephanidis, 1997).

The adaptability of the User Interface to the specific needs, abilities and preferences of the target user group is achieved at design time by means of a User Modelling Tool called USE-IT (Akoumianakis and Stephanidis, 1997a; Akoumianakis and Stephanidis, 1997b). This tool takes the appropriate decisions regarding the lexical characteristics of the dialogue, based on: (a) knowledge about the user characteristics, abilities and preferences, and (b) knowledge about the structure of the lexical level characteristics with respect to the various target user groups (i.e., interaction objects, interaction techniques, devices, etc.). The unified User Interfaces, which are developed by utilising the tools of the U2ID framework, automatically inquire the adaptability decisions generated by the USE-IT tool, and apply these decisions during user-computer interaction.

Unified user interface development makes two claims which radically change the way in which interfaces are designed and developed, while having implications on both the cost and maintenance factors. The first claim is that interfaces may be generated from specifications, at the expense of an initial design effort required to generate them. The second claim relates to the capability of the unified user interface to be transformed, or adapted, so as to suit different contexts of use. For example, in the cases of blind and motor impaired users, the problem of accessibility of a menu can be addressed through a sequence of steps, involving:

- the unification of alternative concrete design artefacts (such as the desktop menu, the 3D acoustic sphere likely for the non-visual dialogue, etc.) into abstract design patterns or unified design artefacts (such as a generalised container);
- a method to allow the instantiation of an abstract design pattern into the appropriate concrete physical artefact, based on knowledge about the user; and
- the capability to dynamically enhance interaction by interchanging or complementing multiple physical artefacts at run-time (see in the following adaptivity examples in the AVANTI system).

3.4.4. Working examples of designed for all systems and services

The unified user interface development method was validated in the ACCESS project in two application domains, namely the development of a hypermedia application accessible by blind people (Petrie et al., 1997) and the development of two communication aid applications for speech-motor and language-cognitive impaired users (Kouroupetroglou et al., 1996).

One of the main concepts arising from the investigations carried out is that the new technology should embed enough intelligence to enable emerging systems to adapt themselves automatically to the needs of different users or to the needs of the same users in different contexts of use. This is one of the reasons why it was previously said that design for all problems in the Information Society are technological in nature. The following fundamental question is whether the investigation of solutions of the technical problems of design for all in the Information Society pointed out is only an interesting conceptual problem, or whether it can lead to workable approaches and solutions.

The technical feasibility of the Design for All approach has been shown in two projects partially funded by the European Commission, where it has been demonstrated that it is possible to implement services and interfaces based on the design for all approach. In these projects, the inclusion of all users has been obtained by implementing systems and services that are adaptable (that is, automatically reconfigurable at run-time, according to knowledge about the user or the user group) and adaptive (that is, able to change their features as a consequence of the patterns of use).

3.4.4.1. The AVANTI system

The EC ACTS AVANTI project (Adaptive and Adaptable Interactions for Multimedia Telecommunications Applications) developed a new approach to the implementation of Web-based information systems, by putting forward a conceptual framework for the construction of systems that support adaptability and adaptivity at both the content and the user interface levels (Emiliani, 2001).

The AVANTI framework comprises five main components (3.6):

- A collection of multimedia databases, which contain the actual information and are accessed through a common communication interface (Multimedia Database Interface - MDI);
- The User Modelling Server (UMS) (Kobsa and Pohl, 1995), which maintains and updates individual user profiles, as well as user stereotypes;
- The Content Model (CM), which retains a meta-description of the information available in the system;
- The Hyper-Structure Adaptor (HSA) (Fink at al., 1997), which adapts the information content, according to user characteristics, preferences and interests;
- The User Interface (UI) component (Stephanidis et al, 1998; Stephanidis et al., 2001), which is also capable of adapting itself to the users' abilities, skills and preferences, as well as to the current context of use.

The above conceptual framework has been applied in the development of three information systems, within the context of AVANTI: the Siena information system, offering tourist and mobility information to residents and visitors of the city of Siena (Italy); the Kuusamo information system, providing information on travelling and accommodation in Kuusamo (Finland) and its surroundings; the Rome information system, aimed at providing cultural and administrative information for the city of Rome (Italy).

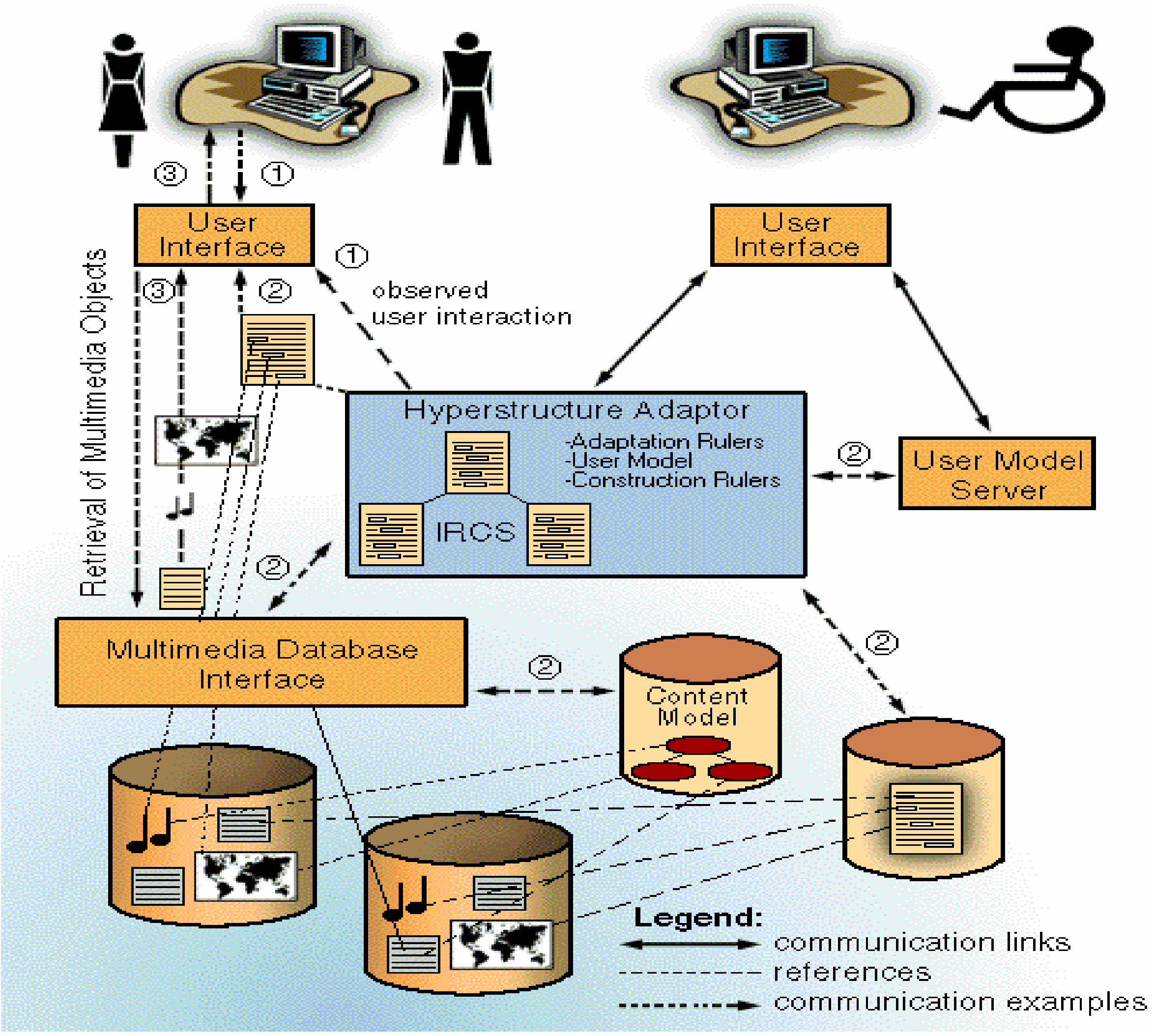


Figure 3.6: The AVANTI system architecture

Adaptations at the information-content level are supported in AVANTI through the Hyperstructure Adaptor (HSA), which dynamically constructs adapted hypermedia documents for each particular user, based on assumptions about the user characteristics and the interaction situation provided by the User Model Server (UMS). The user characteristics that trigger appropriate adaptation types at the content level mainly concern the type of activity limitation, the expertise and the interests of the user. The resulting adaptations mostly concern (Stephanidis et al., 2001):

(i) alternative presentations using different media (e.g. text vs. graphics, alternative color schemes);

(ii) additional functionality (e.g. adaptive "shortcut" links to frequently-visited portions of the system, and conditional presentation of technical details);

(iii) different structures and different levels of detail in the information provided. The knowledge about the user and the interaction session is mostly based on information acquired dynamically during run-time (e.g. navigation monitoring, user selection, explicit user invocation), with the exception of the initial profile of the user, retrievable from the UMS, which is acquired through a short questionnaire session during the initiation of the interaction, or retrieved from a smart card if one is available.

The design and development of the AVANTI browser's user interface (which acted as the front-end to the AVANTI information systems) have followed the Unified User Interface Design Methodology

(U2ID) (Savidis et al., 2001), described above. The resulting unified interface is a single artefact in which adaptability and adaptivity techniques are employed, in order to suit the requirements of three user categories: able-bodied, blind, and the motor-impaired people. Adaptations at the user interface are supported through the cooperation of the browser and the User Model Server.

The categories of interface adaptation supported by the AVANTI UI include (Stephanidis et al., 2001b):

(i) support for different interaction modalities and input / output devices;

(ii) automatic adaptation of the presentation of interaction elements;

(iii) task-based adaptive assistance;

(iv) awareness prompting;

(v) limited support for error prevention;

(vi) limited support for metaphor-level adaptation.

Additional features that have been included in the AVANTI browser, in order to meet the requirements of the target user categories, include adaptive support of multiple interaction metaphors (e.g. desktop application and an information kiosk metaphor), special I/O devices, and extended navigation functionality. Alternative metaphors have been designed for the different usage contexts of the AVANTI system. Furthermore, special purpose input / output devices have been integrated into the system, in order to support blind and motor-impaired individuals: binary switches, joysticks, touch screens and touch tablets, speech input and output, and Braille output.

3.4.4.2. The PALIO System

PALIO (Personalised Access to Local Information and Services for Tourists) is a project funded by the EC's IST Programme. The main challenge of the PALIO project was the creation of an open system for accessing and retrieving information without constraints and limitations (imposed by space, time, access technology, etc.). Therefore, the system is modular and capable of interoperating with other existing information systems. Mobile communication systems play an essential role in this scenario, because they enable access to services from anywhere and at anytime. One important aspect of the PALIO system is the support of a wide range of communication technologies (mobile or wired) for accessing services. In particular, it is possible for users equipped either with a common cellular phone or an advanced WAP phone to access services, wherever they are (Figure 3.7 is an example).

Figure 3.7: Example of the adaptation capabilities of the PALIO system on the website of the Italian network of EDeAN (http://www.it-edean.ifac.cnr.it).

The PALIO system envisages the adaptation of both the information content and the way in which it is presented to the user, as a function of user characteristics (e.g. abilities, needs, requirements, interests); user location with the use of different modalities and granularities of the information contents; context of use; the current status of interaction (and previous history); and, lastly, the technology (e.g., communications technology, terminal characteristics, special peripherals) used.

The PALIO information system consists of the following main elements (Figure 3.8):

- A communications platform that includes all network interfaces, to inter-operate with both wired and wireless networks;

- The AVC centre, which is composed of the main adaptation components, a service control centre, and the communication layers to and from the user terminals and the information services;
- Distributed Information Centres in the territory, which provide a set of primary information services.

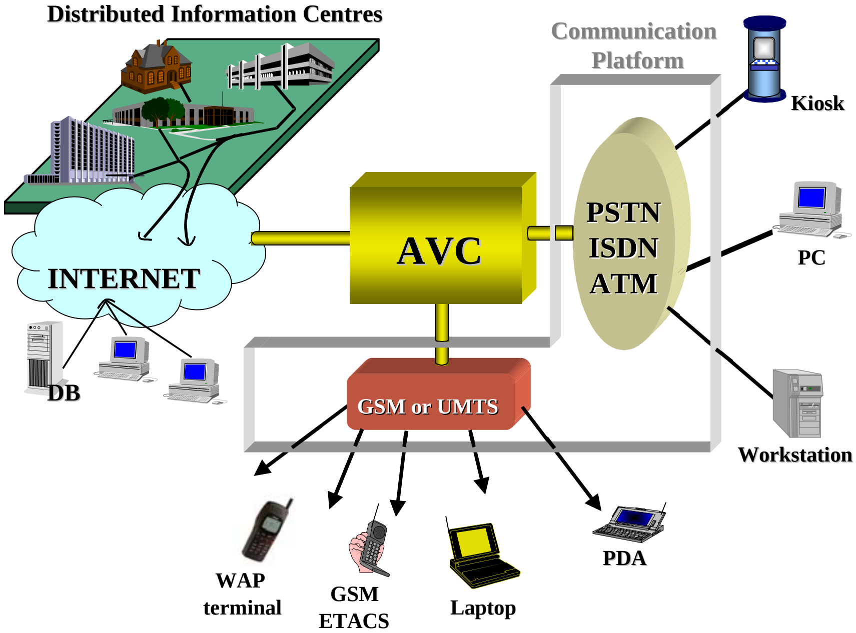


Figure 3.8: PALIO Information system

The AVC centre is the architectural unit which manages diversity and implements the mechanisms for universal access. The AVC will be perceived by users as a system which groups together all information and services that are available in the city. It will serve as an augmented, virtual facilitation point from which different types of information and services can be accessed. The context- and location- awareness, as well as the adaptation capabilities of the AVC, will enable users to experience their interaction with services as a form of 'contextually-grounded' dialogue: e.g. the system always knows the user's location and can correctly infer what is 'near' the user, without the user having to explicitly provide information to the system.

3.4.4.3. The 2WEAR project

2WEAR (A Run Time for Adaptive and Extensible Wireless Wearables) was an IST-funded project (IST-2000-25286) aiming to explore the vision of a distributed personal computing system that is built on-the-fly by combining several different devices. The future mobile will consist of several small and physically distributed devices connected via a wireless communication network. Each of these devices may provide a different function and be integrated in objects worn casually, such as ear-phones, glasses, buttons, pens and wallets. This wearable system will be highly versatile and dynamically extensible allowing the user to combine devices in an ad hoc fashion according to her current needs. It will also be context-aware, being able to sense and seamlessly connect to various devices, exploiting the available surrounding computing infrastructure. For this purpose, software may be dynamically downloaded and activated on the wearable, to be removed when access to these external systems is no longer needed. Applications running on the wearable will adapt their behaviour according to the changing configuration of the system. The system will dynamically adapt its functional and interactive elements, based on the availability of components without having to reset or shutdown running applications. The project developed and experimented with such a wearable system, focusing on extensibility and adaptation issues.

The following key results were produced:

- **Vision and scenarios of adaptive personal wearable system**
  The vision of a distributed and dynamically adaptive wearable personal system was documented in terms of several indicative usage scenarios as well as in terms of simple components/services that can be combined with each other to provide this functionality. While this information served primarily as input for the system development tasks of the project, it does capture an interesting aspect of dynamic composition and adaptation in wearable and mobile systems that can inspire and exploited by a wider audience in the area of pervasive and ubiquitous computing.

- **Interoperable service-oriented architecture**
  A key result of the 2WEAR project was the definition and implementation of an open, interoperable communication architecture based on the notions of components offering services to the system (programs residing on other devices that invoke these services). The project's approach differed from most state-off-the-art communication frameworks as it allows designers to express the desired interactions between clients and servers and can be used to capture a variety of interaction patterns, including request-reply and notification. Last but not least, it can be implemented even on small/embedded platforms with fairly constrained computing resources.

- **Basic service development support on a variety of platforms**
  The above communication architecture was implemented and tested on a variety of different runtime environments, ranging from custom-built devices with limited computing resources to commercial off-the-shelf (COTS) systems such as PCs, PDAs and mobile phones.

- **Support for dynamic and adaptive resource management**
  Based on this core communication support, higher-level dynamic and adaptive resource management functionality has been implemented for (a) user interface resources and (b) storage resources.

- **Really wearable devices**
  Prototypes of wearable devices were produced, hosting elementary services/resources that are exploited by various applications. Despite the fact that such functionality could be emulated using COTS devices, such as mobile phones, PDAs and laptops, one of the key objectives of 2WEAR was to deliver really wearable devices based so that the envisioned system concept and prototype could be demonstrated in a truly "hands-on" fashion. The wearable devices produced are a Wristwatch, a GPS module, a GSM modem module and a general compute module –the last device does not have a specific function but can be used as a small wearable computer.

- **A demonstrator involving several devices, services and applications**
  Several elementary services and a few indicative applications were developed using the implemented hardware and software components. These are all combined into a greater demonstration scenario that involves a variety of heterogeneous devices and platforms, ranging from wearable embedded systems to COTS devices, such as iPAQs and PCs. Having a demonstration that involves real devices and real applications serves a twofold purpose. For developers, it provides a real-world testing environment where various hardware and software components can be tried out to verify interoperability and robustness as well as to experiment with different functionality options. But perhaps more importantly, it allows even casual users who are not computer experts to experience the envisioned system concept in a "hands-on" fashion.

Figure 3.9: The 2WEAR demonstrator infrastructure: (a) the PDA on the left – “GUI machine”, providing Menu and Text Editor services; (b) PDA on the right – “Notepad”, providing Text Display and Graphics Display services; (c) the laptop – “Public devices”, providing a Hi Fi device (five Buttons and one Text Line services), a Keyboard service, a Text Display service and a Graphics Display service; (d) the MASC wristwatch (in front), providing a Text Display, Beep, and four Buttons services; and (e) the MASC module (bottom right), portable processing unit.

The 2WEAR project addressed an issue that is left mostly untouched. On the one hand, projects in the area of wearable computing typically investigate alternative modes of user interaction, special-purpose devices and power management issues. On the other hand, projects in the area of pervasive and ubiquitous computing typically investigate methods of user monitoring and focus on the (reactive or proactive) services to be provided by the “smart environment and infrastructure” rather than the devices carried by the user (and how these fit in the picture). As such, the contributions of 2WEAR are not only important in the context of “the project per se” but do fill a gap between these two mainstream directions of research.

3.4.4.4. Universally Accessible games

The concept of Universally Accessible Games (UA-Games) has been proposed as a means to overcome the limitations of previous approaches to game accessibility, and as an effective technical approach to achieve game accessibility coupled with high interaction quality, also putting forward the objective of creating games that are concurrently accessible to people with diverse abilities.

UA-Games are interactive computer games that:

- Follow the principles of Design for All, being proactively designed to optimally fit and dynamically adapt to different individual gamer characteristics without the need of further adjustments via additional developments.
- Can be concurrently played among people with different abilities, ideally also while sharing the same computer.
- May be played on various hardware and software platforms, and within alternative environments of use, utilizing the currently available devices, while appropriately interoperating with Assistive Technology add-ons.

In other words, a universally accessible game is a game that can adapt its interface and content to best serve the requirements of a specific gamer under specific gaming conditions. Imagine having a palette comprising all of the game elements and their attributes that you can use in order to render a fully customized, personalized, version of the game for each distinct player.

The underlying vision is that through such games people will be able to have fun, cooperate and compete on an equal basis, while interacting easily and effectively, irrespective of:

a) their individual requirements, skills and preferences;

b) the technology they use;

c) their location.

Furthermore, this approach has the potential to render accessible several "physical" games that in their original form are not accessible to several groups of people with activity limitations, e.g., the original chess game is not accessible to blind or motor-impaired people.

UA-Games strongly cater for the needs and actively support the right of all people for social interaction and play irrespective of their individual differences, thus providing a steppingstone towards a more inclusive (and fun!) Information Society.

Creating UA-Games may not be a trivial task, but it certainly is a manageable task. It requires handling and understanding a very large design space, comprising diverse users, operating in several different contexts of use, which may not all be known at design time, and also mapping and transforming all related requirements and (dis)abilities to coherent, usable and accessible interaction designs.

Two examples of UA-Games, developed by the Human-Computer Interaction Laboratory of ICS-FORTH in the context of the Universally Accessible Games (UA-Games) Activity include:

- **UA–Chess[70]: a universally accessible web–based chess.**
  UA-Chess can be played through a standard Web browser. Its distinctive characteristic is that it is designed to be Universally Accessible, i.e., it can be concurrently played by people with different abilities and preferences, including people with different impairments (e.g., low-vision, blind and hand-motor impaired).

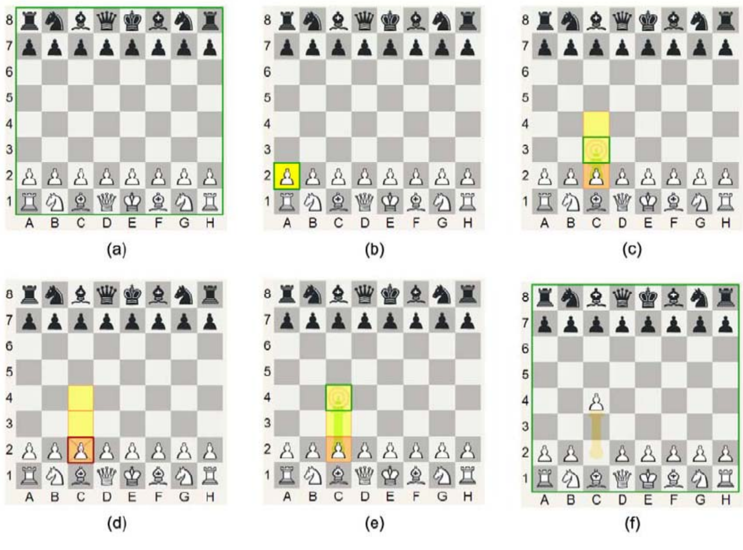


Figure 3.10: Selecting and moving a piece using scanning in UA-Chess

[70] See http://www.ics.forth.gr/hci/ua-games/ua-chess/, last visited on 18 December 2008

This is achieved by supporting alternative input and output modalities and interaction techniques that can co-exist and co-operate in the game's user interface, combined with fully customizable player profiles. Every aspect of the game's functionality is fully accessible through the mouse, the keyboard (or any type of switches emulating keystrokes) and speech recognition. UA-Chess has self-voicing capabilities, since it includes a built-in screen reader that offers full auditory access to every part of it. Additionally, the game can be sized according to user preference and zoomed in and out at different levels. Finally, several alternative interaction techniques (the parameters of which can be customized) are supported for each device.

- Access Invaders[71]: a universally accessible multiplayer and multiplatform version of Space Invaders.
  Access Invaders is a fully-functional game,. The game can be played in Windows and GNU/Linux. It can be concurrently played by individuals with different abilities and preferences, including people with disabilities, e.g., low-vision, blind and hand-motor impaired. The game is highly customizable and supports the creation and use of unlimited user profiles. Each game parameter can be customized both based on the player's profile and the current game level. An unlimited number of players is supported. The game can be played using the keyboard, the mouse, a joystick, and one, two or three switches (or even more). It also features spatial (3D) sound and a screen reader (for presenting textual information), so that it can be played by blind people too. Vision–based gesture recognition through a standard web camera can be used to track hand movement and recognize palm and finger gestures. Moreover, musical input in the form of individual musical notes, irrespectively of the instrument used to produce them (e.g., by whistling, knocking a spoon against a glass, playing the guitar or the piano, or even singing) are recognised and mapped to game controls.

Basic profile

Single switch profile

X-Large profile

Non-visual profile

Figure 3.11: Different interaction profiles for Access Invaders

[71] See http://www.ics.forth.gr/hci/ua-games/access-invaders/, last visited on 18 December 2008

UA-Chess and Access Invaders constitute practical demonstrations of the application of Design for All principles, methods and tools in the development of software applications. In the overall context of promoting Universal Access to the Information Society and raising awareness in the software development community about Design for All issues, these games can be seen as a good practice example, demonstrating that Universal Access is a challenge and not utopia. Furthermore, these two games strongly cater for the need and actively support the right of all people for social interaction and play, irrespective of their individual differences, thus providing a steppingstone towards a more inclusive (and fun!) Information Society.

4. The near future

4.1. Introduction

As already mentioned in Chapter 1, the European society is in transition toward an Information society. This transition is producing changes in the way many classical activities, as interpersonal communication through a network and access to information, are carried out, but it has more important implication for the impact of ICT in all human activities: education, work, entertainment and so on. This is caused by the reorganisation of the society as an interconnected intelligent environment. Interacting with this environment and intelligent objects in it human beings are supposed to live and carry out all their activities.

From a conceptual perspective, there is a change from a model based on products (computers, terminals) and activities (tasks) to be carried out through them to a model in which functionalities are made available to people, irrespective of their real technical implementation. From the perspective of users, including users with activity limitations, there is a fundamental change from an approach based on adaptations of products to be accessible, giving the possibility of carrying out necessary activities, to a situation where the emphasis is on goals of people, which the environment should be able to infer and support with functionalities adapted to the capability of the single user.

This is obviously a long term development scenario. However, the migration toward this new situation is under way and some of the concepts at the basis of the ambient intelligent paradigm are starting to be used, leading to AmI-like environments, which exhibit some of the functionalities (services) foreseen in the future development scenarios.

This chapter tries to catch some aspects of this transition from the perspective of people with activity limitations. Section 4.2 will describe some of the emerging smart environment, trying to point out the main opportunities and problems for people with disabilities. Section 4.3 will examine some of the ongoing technological developments connected with the emergence of AT and AmI like environments. Section 4.4, as an introduction to next year deliverable that will deal with research activities to carry out to favour the implementation of an accessible AmI, will give examples of the fact that a correct use of technology in development could lead in the short-medium terms to improvements of the situation of people with activity limitations, both through improvements in the Assistive Technology itself and through the implementation of more useful and acceptable AmI-like environments.

4.2. Integrated systems

4.2.1. Present situation

Ambient Intelligence (AmI), which is widely recognised an one of the most likely evolutions of the Information Society, has the potential to offer a global vision of the possible organisation of human activities related to access to information, interpersonal communications and environmental control.

Many technologies, systems and services mentioned in the scenarios describing the possible future organisation of the Information Society are not fully available, but at a conceptual level they seem to represent a significant answer to some of the people’s living problems. Therefore it is interesting to discuss if it is possible to construct AmI-like environments, that is environments that incorporate at least some of the AmI concepts, in an evolutionary way, by exploiting available technology as well as its integration and intelligent control, while supporting future evolutions at the infrastructure level and at the level of interaction with personal systems and devices. This can be achieved through the design and incremental implementation of always-on pervasive but friendly and not-invasive communication and information environments, able to assist users anytime and in varying context, integrating suitable sensors and available communication facilities, and being able to adapt and evolve according to the needs of the users.

Following two originators of the AmI vision (Aarts and Marzano, 2003), Ambient Intelligence is defined according to its properties:

- Technology is **Embedded** in the physical and social environment of people;
- Technology is **Context Aware** - employing machine perception a model of activities of people and their social and physical context can be obtained;
- Technology is **Personalized** - addressing each user as an individual person;
- Technology is **Adaptive** to context and activities of the person;
- Technology is **Anticipatory** - predicting user's needs and taking action to support them.

Implementations of AmI-like approaches (that is integration of ubiquitous computing and communication with intelligent user interfaces) have already been in use for some years. Solutions based on, for instance, RF technology, Bluetooth, WLAN or global positioning systems have been used to get information or to communicate with devices in the environment. Some work has concerned the embedding of computation in every day artefacts (for example with the eGadgets projects of the IST programme (IST-2000-25240)[72] and the Smart-Its project (IST-2000-25428)[73]).

As an example of the industrial interest, it can be reported that several very interesting projects have been carried out by Philips regarding AmI like environments (Aarts, 2006).

In their Windows to the World of Information, Communication and Entertainment (WWICE) project Philips has set up an apartment like structure with AmI like facilities (Figure 4.1). In this apartment Philips is experimenting the "Follow Me" scenario, in which activities follow people as they move through the home. Thanks to wireless connections it is possible to design systems whose functions are not restricted to a particular position in the home, but are available throughout the home. One of the scenarios analyzed in "Follow Me" concerns the freedom to seamlessly continue media activities, such as listening to music and receiving video phone calls, while moving at home.

Figure 4.1: WWICE 2 is a project about the Connected Home. A new user interaction concept called 'spaces' has been developed. A space is a virtual room where people can meet and share content and experiences. . Source: Philips, http://www.research.philips.com/newscenter/pictures/systsoft-ambintel.html.

72 http://iieg.essex.ac.uk/egadgets.htm
73 http://www.smart-its.org/

In the Phenom project, Philips has set up a solution for instant access to photo albums from anywhere in the home. The system allows to show photos on the nearest TVs as well as forms of associative browsing, and memory sharing, with the possibility of entering into dialogue with the system by simply placing a souvenir on the table.

In the Your Media Environment project, Philips investigated the use of Semantic Web for reasoning about context and showed that this could be applied to choose music to play on a mini audio system according to the situation and the presence of users.

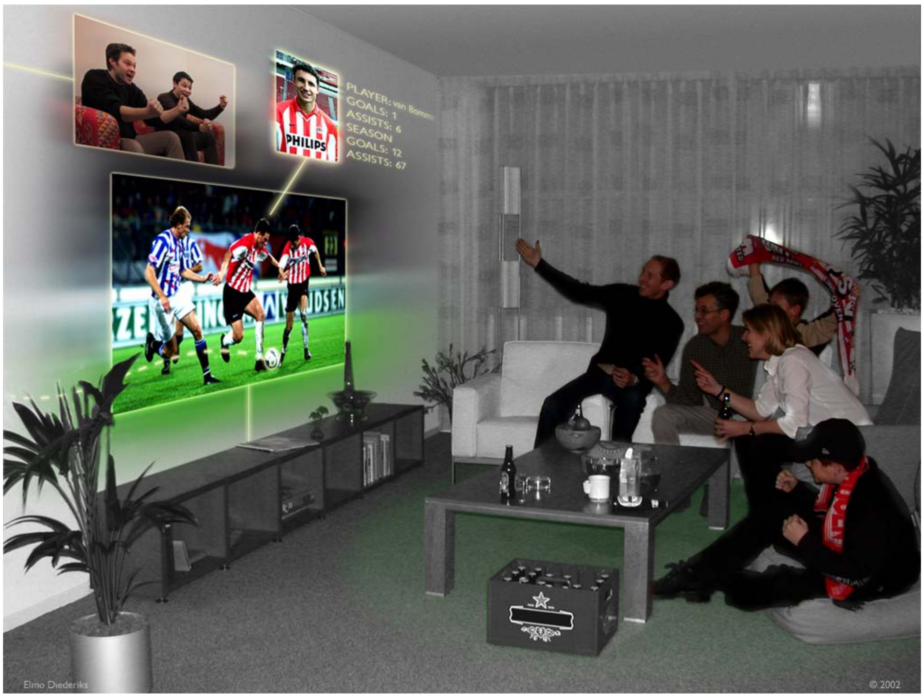


Figure 4.2: Augmenting broadcasted content by sharing experiences. Source: Philips, http://www.research.philips.com/newscenter/pictures/systsoft-ambintel.html.

In the Emotion–sensing chair technology is integrated in the fabric of everyday life and the chair can sense, record and transmit human physiological parameters such as heart rate or muscle strain.

Finally, the Intelligent LifeStyle Assistant system is an intelligent and adaptive home environment system to support older occupants of the home. The system includes an intelligent monitoring system based on the integration of sensors and a context aware reasoning engine to translate data into meaningful events. Benefits include helping older people in maintaining an independent life style, enhancing the feeling of safety, provide a monitoring service to alert relatives, delaying the need to live in care facilities, allowing care providers to focus patients with higher risk, reducing the visits to hospitals by elderly people for checkups.

Research in context awareness has produced significant progress in machine perception (e.g., through vision, or multi-modal pattern recognition) and the development of context aware services (e.g. location aware mobile services that are reaching the market).

Future AmI environment must take care of contexts of use. Recently, research tendencies have evolved to consider context not statically, but as a process, defined by specific sets of situations, roles, relations, and entities (see Coutaz, 2005; Coutaz, 2002). This seems promising to allow to cope with complex situations related to interaction with AmI: in fact, in the ubiquitous interaction with information and telecommunication systems the context of use may change continuously or abruptly and the same systems or services may need to behave differently in different contexts. For example, a user might be carrying out some activity in a room (for example, in the kitchen), invoking some AmI functions, when a second person enters the room. The system must then reconfigure itself, not only due to the possible introduction of some additional intelligent component, but also because of the change in the context of use. The system must now accommodate the original goals of two persons, and also take into account their interaction, which, for example, may redefine in real time some of their goals or change the time scale of different activities (Burzagli, 2007).

Personalization and Adaptation have concerned up to now mostly on line services and the delivery of hypermedia content, e.g., recommender systems, but some applications in the smart home environment are appearing in research demonstrators.

However, even though technology in terms of devices has evolved, the field is fragmented and the lack of interoperability and communication between such devices and systems hinders the development of systems that are able to provide e.g. automated care giving and vigilance, which is essential for allowing the autonomous living of older people and people with activity limitations.

Apart from professional and educational environments, so far the main interest in AmI like technologies and services-applications has been in the smart house environment as a support both to the individuals and to the caregivers. More recently the concept of Ambient Assisted Living[74] (AAL) (IST results, 2006) has been developed. In this section the importance of this technology in allowing access and inclusion to the society at large will briefly discussed.

In addition to the fragmentation of the corresponding market, it must be considered that national differences as for organisation of social care and culture exist (Steg et al., 2006). There also seems to be a lot of knowledge about accessible housing, but less interest is devoted to related services that will probably play a fundamental role in favouring inclusion. Also user involvement is essential in order to produce environments where people can live, move, study, work, and socialise. The user point of view implies also ethical issues, which include, for example, the person's possibility to control the system and privacy. It should be possible for the user to switch the systems on and off and change the rules according to which they operate.

In order to achieve the goals of users, the five main orientations in Europe's ICT research effort are (IST results, 2006):

1. Addressing complexity and the need for a system approach. The successful exploitation of the AAL technologies requires the integration in managed services[75] and solutions to be applied across broadening range of sectors and markets;
2. Fostering interdisciplinarity and synergies. There is a need for stronger involvement of domain expertise and for greater interaction with other science and technology disciplines. Thus the range of interactions around ICT research and development must be both wider and deeper;
3. Creating an open engagement with users. Users should be integrated into the processes of research and development, and new product creation and introduction. Users should be at the centre of the innovation process, a source of ideas, and not just a resource to evaluate ideas generated by professionals and a potential market;
4. Stimulating the consumption side (services and content). Networks become service- and application centric and will be visible for the user;
5. Focusing on value chains and ecosystems. Successful exploitation of ICT research results requires not just innovative technology but also innovative business models. While keeping

[74] Ambient assisted living is an instantiation of the general AmI environment. In the following the locution AmI-like environment is used.

[75] The interest on services and the fact that they are managed is important (management means intelligence in the system).

user needs centre-stage, the user focus needs to be shifted from discrete systems to the value chains of which they are a part and the societal challenges to which they are applied.

The efforts should lead to an ICT that "will enable the creation of systems that are more intelligent and personalized, and therefore more centred on the user" (IST results, 2006). In the end the user is the key factor in realizing the goal of improving the quality of life for people with activity limitations.

It is particularly interesting that the above considerations are made not at the level of single technologies, (intelligent) objects, and interaction, but at the level of systems and services. What is spreading around is the idea that the analysis at the user level must be carried out through the analysis of services and applications users need to access information, communicate and control the environment and not at the level of single technologies and artefacts. First, it is necessary to discover what the user need (functional level) and then how and up to what point the needed functionalities can be granted with available technology.

According to the World Health Organisation (WHO) the estimated number of people who require rehabilitation services is continuously increasing (1.5% of the entire world population - 2003). Unfortunately, the available solutions do not fully match their needs. According to the World Health Organisation disability is a condition in which people are temporarily or definitively unable to perform an activity in the correct manner and/or at a level generally considered "normal" for the human being. Following this vision, a critical reason for developing AAL environments lies in their potential to compensate or expand people's activities through new forms of support and human-computer interaction.

In this section the importance of the Ami-like approach and technology in allowing access and inclusion in the society will be briefly discussed, with particular reference to services and applications that may be made available with available technology.

4.2.2. Users in AmI-like environments

ICT has potential usefulness to users with activity limitations (including people with disabilities and older people), who often require to be "assisted" to reach independence in their life. This population needs "Design for All" considerations to interact easily and efficiently with the technical infrastructure and the potential services and applications.

In order to take advantage of the new possibilities offered by the technological developments it is necessary:

- to exploit existing sensorial, computing and networking technology and their integration in an ambient infrastructure transparent to the user;
- to produce intelligent human machine interfaces based on the modalities of natural human interaction;
- to develop designed-for-all services and applications that will assist the user to cope with their possible activity limitations;
- to take advantage of research in the fields of cognitive systems, computer vision, monitoring and event recognition, reasoning, natural human-computer interaction, data and media collection, handling and presentation;
- to integrate sensors and services/applications in an intelligent control system.

In the following some of the problems of users with activity limitations will be considered and some suggestions about the type of support that they could have by services and applications in AmI-like environments will presented. The presentation does not pretend to be exhaustive, but to give a glimpse of the possibilities in development. More precisely, the problems of people with cognitive impairments will be mainly considered in the discussion as examples, due to their social relevance in connection of the growing number of older people.

As a matter of fact, the major trend throughout Europe is the aging of society caused by an increasing life expectancy and decreasing birth rates. Not only the group of people over 65 is supposed to become a large proportion of the European society but there will also be a significant increase in the number of people over 80. The proportion of population aged 65 and over is rising in all countries. However differences can be observed. The ratio for Iceland, Ireland, Slovak Republic and Turkey lie well below the average for Europe, whereas the ratio for Finland, Germany, Greece, Italy and Sweden lie far above the average for Europe (OECD, 2005).

"It is a common understanding that population ageing, along with the increasing survival rates from disabling accidents and illnesses, will lead to an increase in the proportion of the population with impairments, disabilities or chronic illnesses." [European Commission, 2004] For instance the number of people with dementia in The Netherlands is expected to rise from 250 000 in 2005 to 350 000 in 2020 and over 580 000 in 2050.

Complex human behaviour requires three fundamental abilities: (1) the ability to *comprehend* the world, (2) the ability to *plan and act*, (3) the ability to *communicate*. Therefore, cognitive resources are crucial capacities for successful and independent ageing (e.g. Park, 2000). Cognition comprises human information processing functions and domains that allow people to access and maintain knowledge. Relevant domains are, for example:

- memory;
- language;
- orientation;
- problem solving.

Impairments of cognitive functions such as recall and recognition (e.g., the ability to identify faces, objects and events), attention, learning and executive control processes interfere with daily functioning and severely degrade the quality of life. Regardless of its severity, cognitive impairment results in diminution of social contact, leads to social exclusion, loneliness and depression.

As an example, let us consider the Alzheimer's Disease (AD), which today is the most common form of dementia. Alzheimer's disease is age-associated, that is, it affects primarily older adults and its prevalence increases with advancing age. It is a slow and progressive, degenerative disorder of the brain that eventually results in diminished brain function and death. The Alzheimer's disease results in impairment in the cognitive and adaptive skills necessary for successful personal, community and occupational functioning. Produced changes include memory loss, personality changes, and diminished self-care abilities, including e.g. abilities to eat and use the toilet. People with dementia, for example, may have difficulty naming objects or maintaining a logical conversation, understanding directions or instructions and may become disoriented as to the time.

People suffering from Alzheimer, even at the beginning of the illness, when they are mostly independent in everyday life, need specific support in specific contexts mostly for memory problems. Its most prominent form, dementia can render the affected subjects incapable of taking care of themselves. They may have difficulties and also be in danger for:

- the negligent practice of therapy (e.g. forgetting to take medication);
- wandering around;
- being unable to locate everyday objects (e.g., glasses, hearing aids, medication, telephone, etc);
- forgetting important appointments;
- being subject to household-appliance related dangers.

When the illness has critically evolved along years the user must be fully supported in a wide range of activities.

It is evident from the above short description that dementia has a feature, i.e. variability, that directly asks for the development of AmI-like environments. Each personal situation is different, varies continuously in time, and needs applications that are personalised, adaptive and anticipatory. Therefore, any technological system (e.g. a smart home) deployed in the society in order to support citizens, particularly citizens with activity limitations, must have enough embedded intelligence to ensure automatic detection of events, and automatic, reliable decisions on the actions to perform upon an event occurrence.

So far most examples of AmI-like applications have been in the home environment. However it is also important that people, as far as possible, are given the possibility to move around independently at least in their normal living environment. In addition to the obvious difficulties that people with dementia as described above may have in moving around in the environment, an example of a situation that impairs particularly the capacity of independent mobility are people who suffer from topographical disorientation disorder, particularly topographical amnesia. This disturbance impairs the memory of environmental landmarks, the physical characteristics of which are correctly perceived but not remembered, the ability to recall the location of different spatial landmarks and to find one's way in new environments. The main problem is in learning and remembering new paths, to reach different target locations.

As it appears clearly from the short description above, a person with impairment in cognitive functions may need AmI-like environment as:

- support in carrying out normal tasks in the house, in order to be able to live independently;
- control in different environments for avoiding possible dangerous situations;
- support in navigating in different environments for being connected with other people;
- control of their health care condition.

Moreover the environment is also supposed to support caregivers in their professional activities.

Finally, it is important to consider that the personalisation level of the environment must be planned and adapted in time through the cooperation of user themselves, as far as possible, their families and the caregivers. Moreover, a careful training of the user is necessary. This is essential for the acceptance by all the involved stakeholders. The users must receive feedbacks in ways and formats they feel comfortable with. They must feel to have control on the system and to be able to maintain their autonomy without feeling supervised and controlled during their activities, when not necessary for security reasons or for the advancement of the illness. The family must feel confident about leaving their relatives alone at home several hours a day. The professional caregiver must feel that the assisted living system allows a continuous assessment of the patient's daily evolution in their environment. Thanks to this constant monitoring the professional caregiver must feel able to propose adaptations of the system to the evolving needs and capacities, and to offer additional services to the users.

In addition to supporting users in their independent living, AmI like environments, when necessary, must be able to take care of the monitoring (including the health-care situation) of people and support the caregivers (family and professionals). On a global level monitoring can be divided in the following categories:

- Active alarm systems– usually telephone based – installed in the house;
- Passive alarm systems, not requiring the interaction of the person (e.g. sensors that are able to recognize the danger of a fire and send an emergency call automatically);
- Remote support for care staff;
- Remote support for family carers;
- Remote monitoring and video-based alarm services;

- Telemedicine (European Senior Watch Observatory and Inventory, 2002).

In order to serve users in the most efficient and acceptable way, an in depth analysis of human activities of daily living in the different environments must be carried out. For example in the home environment, the Activities of Daily Living (ADL) are basic tasks of everyday life. They are standard assessment criteria for the functional status of a person. ADL are, according to the Katz Index of Independence in Daily Living (Katz et al., 1970), feeding, bathing, dressing, toileting, transferring to bed or chair and continence. People who are unable to perform ADL need help from caregivers or Assistive Technology, or both. More in general Instrumental Activities of Daily Living (IADL) are more complex activities not necessarily done every day, but crucial for independent living. The IADL scale is a screening tool to assess if a person is able to live independently (Lawton & Brody, 1969). The scale includes the ability to use telephone, shopping, food preparation, housekeeping, laundry, transportation, medication and handling of finances. Specific IADL items (telephone use, transportation, medication, and handling finances) are significantly correlated with cognitive impairment (Bargeberger-Gateau et al., 1992). Symptoms associated with Alzheimer's disease are also significantly related to IADL (Tekin et al., 2001).

Therefore it is necessary:

- To analyse instrumental activities of daily living in the different environments and to formalise the description of user behaviour patterns;
- To understand what basic ADLs (Activities of Daily Living) are "key" to independent living and what are typical human errors that the system could guard against, from e.g. a cognitive aging perspective, in order to inform system design and development efforts;
- To detect and managing the negative effects of interruptions in typical daily activities such as preparing meals or disruptions of a daily routine such as waking up, preparing breakfast, watching TV, exercising, etc.;
- To recognise the many variations of common activities focusing on extracting the user's usual behavioural patterns, which the system will characterize as "normal" and consequently track down behavioural patterns that deviate significantly from the normal patterns and the system will characterize as "abnormal", thus leading to the detection of potential emergencies (e.g. detect falls from body posture patterns);
- To identify the most suitable ambient user interfaces.

Although ADLs (Activities of Daily Living) provide a framework of human activity, it is necessary to understand how these activities are enacted on a day-to-day basis and how these routines are interwoven.

4.2.3. Some environments of interest

With a focus on the functionalities available to the user Aldrich proposes five hierarchical classes of smart homes (Aldrich, 2003) that can be generalised to any AmI-like environment:

1. Environments which contain intelligent objects – environments contain single, standalone applications and objects which function in an intelligent manner;
2. Environments which contain intelligent, communicating objects – environments contain appliances and objects which function intelligently in their own right and which also exchange information between one another to increase functionality;
3. Connected environments – environments have internal and external networks, allowing interactive and remote control of systems, as well as access to services and information, both within and beyond the environment;

4. Learning environments – patterns of activity in the environments are recorded and the accumulated data are used to anticipate users' needs and to control the technology accordingly;
5. Attentive environments – the activity and location of people and objects within the environments are constantly registered, and this information is used to control technology in anticipation of the occupants' needs.

So far most of the AmI activity has been in introducing intelligence in the single objects, in interconnecting them and in developing natural interactions with the objects themselves and with the environment trough them. Since broadband is becoming more widespread, available smart environments are shifting within the hierarchy from environments which contain intelligent, communicating objects to connected environments. According to CENELEC, the European Committee for Electro-technical Standardization, this the minimum level to have a substantial contribution to the quality of life, since this is necessary for the delivery of telecommunication services to the environment.

Let us now examine some of the environments from the user/service perspective.

4.2.3.1. Improving the home environment

It is commonly accepted that one way to improve the quality of life of people is by making their living environments, e.g. the home, a more comfortable place to live in by turning it into a smart home environment. As a matter of fact, according to the Smart Homes Association the best definition of smart home technology is: the integration of technology and services through home networking for a better quality of living (Roe, 2006).

Within the eEurope context a working model of the Smart Home environment has been defined, with its three separable interest areas as follows (Tronnier, 2003):

1. The Smart House/Home and its in-house networks and applications;
2. The access point to the Smart House, often referred to as residential gateway;
3. Provision of services in a standardized way to the Smart House and related access networks.

Technology products, services and applications may play an important role in creating benefits for users. They are normally divided into six categories, even if the different categories overlap:

1. Comfort;
2. Home management;
3. Multimedia and entertainment;
4. Healthcare;
5. Security and Safety;
6. Communication.

It is impossible to give an extensive overview of the available technology in this chapter, since new products and services are being developed very rapidly and are continuously reorganised in applications of increasing complexity. However some examples are offered as a basis for discussions in the chapter.

A smart home is populated by domestic equipment, including e.g. heating systems, cooking, white appliances (dish washer, washing machine, freezer etc.), home entertainment devices (radio, TV, Video recorders etc.), telecommunications devices (telephone, video telephone, fax,), safety alarm systems, health monitoring systems, home safety monitors and sensors (water, smoke, fire, stoves, movement, etc), special furniture (e.g. electrically adjustable beds, cupboards and washbasins), and environmental control systems (door telephones, doors, curtains, windows, lights etc.). This kind of equipment, which is becoming itself intelligent, is interconnected to offer applications to the inhabitants in cooperation with services and applications made possible by the availability of broadband networks.

Examples of typical applications in the home environment are:

- **Safety**: this application aids in minimizing household hazards caused by user negligence or forgetfulness, raising alarms for critical events, helping the user in facing them, and also proactively controlling devices to avoid accidents. Additionally, the user's well-being is monitored, and in case of any harm, related actions can be performed. Proactive assistance is initiated by the Smart Home by switching off dangerous devices (e.g., ovens), offering communication options to elderly people, or by automatically notifying family members, caregivers, or emergency services. There are already personal safety devices capable of monitoring a person's activity level and sending an alarm automatically when unexpected changes are detected;

- **Security:** the application provides the means for granting access to physical spaces and e-services. Furthermore, possible security problems can be spotted (e.g., somebody breaking into the house) and appropriate action can be taken;

- **Nutrition and medication**: the application provides active reminders and support to proper receipt of medication and nutrition, making sure that the users do not accidentally miss a specific meal, or do not take their prescribed medication at a predefined time. It can support users in their daily selection and preparation of meals, suggesting foods, ingredients and recipes based on personalized dietary information.;

- **Health care:** this application is responsible for monitoring health-related data of the users, regularly reporting them to the carers and notifying them for unexpected measurements;

- **Social engagement and leisure**: this application can provide the means for social engagement and leisure and stimulating ambient interactive experiences that combine entertainment with physical, mental and social activities, thus aiding in the preservation, or even improvement, of the mental and physical health;

- **Administration and scheduling**: this application helps users with the administration and running of their household. For example, home supplies (in relation to the person's needs, habits and preferences) can be monitored and, if running low, appropriate suggestions for action can be made to the users. In case of shortage of vital articles, the carers will also be notified. The day-to-day home management (e.g. energy monitoring) is appropriately organized by the application. Necessary actions can be automatic or, when needed, reminded to the users.

Examples of additional possible applications include:

- **Object location**: the user is firstly guided to look for the objects that s/he is seeking at predetermined positions in the environment. Alternatively, the objects can signal their presence (e.g. using RFIDs);

- **Task-specific assistant with context-sensitive help**: for example, if a task is disrupted for any reason (e.g., the phone rang) and the person does not resume it after the disruption, the system can remind the person of the fact and suggest adequate actions to be taken. Alternatively, if the person initiates a task and seems unable to complete it (or if s/he requests help) the system can provide related information;

- **Communication tools**: interoperating communication tools, adapted to the interaction needs and requirements of the users, can be made available. These tools allow users to be able to easily and effectively communicate with their friends, family and carers. Easy-to-use telephones with pictures have been tested by people with dementia (Topo et al., 20002). The tested telephones were found useful to ease the finding and dialling of numbers, and in some cases even help to remember who called and what was discussed.

- **Remote home access and supervision**: if necessary, carers and relatives of the users can be made aware of the health state of the person, be notified about critical events and perform related actions remotely.

Obviously, care must be given to ensure that only authorized persons have access to this information and are granted remote access rights. Data about the person's state must be transmitted which are directly relevant to the reason for which they are being transmitted and to the role and rights of the person receiving them. The person being monitored must be aware of the fact, know what information is being transmitted and to whom, and given the possibility of deciding to turn off any of these tools. Exceptional cases must also be identified, where trade-offs between privacy and well-being may have to be made.

One of the problems in the smart home environment is that the stakeholders when building intelligent environments are very diverse. They all play a different role in the process and have different preferences and opinions. Therefore, the challenge is not only to develop concepts that are technically possible and reliable but to create a concept that is supported and accepted by the large group of stakeholders. Stakeholders are for instance architects, housing corporations, project developers, electricians, builders, care takers, service suppliers, product suppliers, advising agencies, insurance companies and last but not least the end consumer.

In recent years smart home technology was mostly implemented in new homes. This meant that smart home technology had to be fitted into the existing building process. In Sweden, for example, a specific consultant in the area of smart home technology was added to the project team. This consultant operated together with the architect, the structural consultant, the mechanical consultant and the electrical consultant (Sandström et al., 2005). Instead, in most projects in the Netherlands there is no specific smart home subcontractor or consultant for smart home technology. The electrical sub contractor is responsible for the implementation of smart home technology. More specialized electrical subcontractors call themselves system integrators in order to express their knowledge about smart home technology.

With respect to the building process it is important to realize that the possibility to make changes without huge investments declines during the building process (Willems, 2003). At the starting point of a building process the main decisions are taken by architects, project developers, housing corporations and on very few occasions by the end consumer. Therefore it is remarkable that the parties who are going to benefit from the smart home technology only get to express their preferences during a stage in the building process where changes to the original plan are very expensive.

4.2.3.2. Moving around

The capability of moving around is particularly important for independent living.

Different levels of mobility are necessary:

- Moving around in a known limited environment (e.g. an hospice, an hospital or other living community structures);
- Moving around in a known structured open space (e.g. a park);
- Moving around in an (unknown) general environment (for example the user neighbourhood).

For supporting people moving around in a known environment (as an example, a hospice or another living structure), it is necessary:

- To provide information about activities and available facilities, in the different rooms;
- To provide real-time information about what happens in the different rooms;

- To provide information about where other inhabitants are, provided that they are willing to make this information available (privacy issues are important in this respect);
- To monitor the health status of the user through wearable sensors, when necessary;
- To guide the inhabitants through the hospice, should they encounter difficulties (e.g. due to memory problems).

Data coming from sensors (position, status and actions of users, etc.) must be collected by a central system, able to control the entire living environment. On the basis of the received data, it performs the proper tasks (light control, window or door opening/closure, guidance through the building, connection with other inhabitants, and distribution of information). Furthermore, the control centre can receive data coming from sensors aiming to monitor the user's health or emotional status, allowing carers to intervene timely, when necessary.

For moving in a known open space, the space itself, e.g. the park, must be equipped with technology (Wi-Fi connectivity, sensor networks, etc.), aiming to support people with various types of activity limitations. The system in the park must continuously monitor the location of people and their health status, when necessary, advising the users themselves and their carers in difficult situations, and efficiently guide them through the park itself suggesting paths and facilities matched to the abilities of individual users.

Finally, it can be considered that the city streets are in many cases the core point for social and entertainment activities for the community that lives and works in the neighbourhood. Actually, the street is the privileged space for a continuous exchange of services, information and goods. These social activities can be enhanced through a modular system based on interactive city furniture located in public meeting spaces and through the integration of fixed and mobile networks. The urban architecture plays an important role in mediating those exchanges and can improve existing and enable new activities. The integration of sensors and technology within urban artefacts, in cooperation with a navigation system can enable the establishment of new urban spaces as access points to information and services in order to support existing and emergent, individual and collective activities.

In this case the system must support safe navigation, as well as participation in social activities which are held in the city. The AmI-like system can offer local support, for example when crossing the street, and provide information enabling people in the environment to find the proper path for navigation toward a chosen place, according to their physical conditions and capabilities. Sensors in the street, in cooperation with navigation systems, can be used to drive the user following a safe path, while the system is providing useful information regarding the inclination of the street, the typology of the ground, highlighting boundaries for pedestrians and for drivers and inform car drivers of the presence of a person needing particular attention, thus improving also the driver's safety. Even if the standard GPS navigation system is not precise enough for this type of fine guidance, new navigation systems are under development (Galileo) that will make it possible.

An innovative pervasive communication environment populated by sensors and communication facilities is needed. This environment must be able to support, assist and monitor each user in a personalised and adaptive manner. Moreover, the environment must also be able to describe its features in a personalised way according at the user needs, requirements, and preferences. This concept can for example be introduced through the implementation of speaking and interactive objects in the environment as for example semaphores, poles, etc.

Dealing with mobility, a special group of people who may need support is the drivers (including also drivers with some activity limitation). Digital maps have large potential for traffic optimization or assistance applications not only to position traffic hazards but also to enhance or enable preventive and active driver assistance applications.

Technology for implementing the functionalities outlined above is available, even if it is not yet deployed in an integrated way, particularly for the difficulties related to the intelligent control of the entire system. However, individual functionalities are being made available, at least in experimental installations.

4.2.3.3. Safety and health care

Alarm systems play a very important role in AmI-like environments. The existing solutions include active systems, passive systems to detect falls and domestic risks, electronic prompts and memory aids, specialised telephones and videoconferencing. However, the systems, existing so far, are very often too complicated or not reliable enough. The key issue is the setting off of alarms. If, for instance, persons have an accident (fall, injury), a fire breaks out or a person suddenly becomes unconscious, then there is normally no time or possibility to operate a telephone or even an alarm button on their wrist or around their neck. There is still a large knowledge gap as to how persons react in a dramatic situation, be it panic or a collapse or simply because they are confused or have memory problems (they may forget that they are wearing an alarm button).

A second problem is connected to false alarms. Normally, the receiver of the alarm (e.g. call centre or relatives) sends back a signal to the user for instance by telephone or via a message that appears on the alarm module worn on the wrist or around the neck. In the case of a false alarm, the user can answer the phone or press the button of the module indicating that no help is needed thus avoiding unnecessary attendance. If, on the other hand, the user does not react, it can be assumed that the alarm is serious (Hampicke, 2004).

Probably the best solutions to overcome these problems are passive systems. Passive means an automatic control of vital functions (e.g. pulse, blood pressure, oxygen saturation), their evaluation and an automatic alarm being set off when the values of the vital parameters exceed predefined limits. The reliability of the alarm being set off can be dramatically increased when several different observations and decisions are combined. Among the measurement of vital parameters as described above, the person’s activity (leaving and entering rooms, using water, electric light, TV and radio and many more) can give important additional information.

Apart from alarm situation, an area that receives an increasing amount of interest for reducing health care costs is tele-monitoring or personal health monitoring. Health care monitoring enables continuous measuring of physiological parameters and of the environmental situation. It is possible to embed sensors in different places or objects in the environment (e.g. in the furniture, electrical appliances) or to make them wearable by integrating them into clothing "Smart Shirt" or small apparel items such as watches and jewellery. By combining these wearable sensors with measurement devices embedded in home surroundings, advanced multi-parametric health monitoring may be achieved (Korhonen et al., 2003).

Recording of physiological and psychological variables in real-life conditions could be especially useful in management of chronic disorders or health problems; e.g. for high blood pressure, diabetes, anorexia nervosa, chronic pain, or severe obesity (Korhonen et al., 2003). Tele-monitoring could also be used to provide feedback about someone’s health in the form of behavioural feedback in order to prevent diseases.

Tele-monitoring has many advantages for both, the patient and the medical institutions. The patient can stay at home and does not have to visit a doctor or to go to hospital for periodic routine controls and the medical institution does not have to spend time with routine work. In several tele-monitoring applications the data are not directly transmitted to the medical institutions but to a kind of ‘call centre’, which performs a first data evaluation.

More than 50% of chronic patients sometimes fail to fulfil their treatment and 10 % of admissions that take place in hospitals are directly related to patients who have not followed their treatment correctly. An interactive system can allow the user to follow health protocols and care planning, reminding the patient to do the tasks scheduled by the health service. The advantages increase if the interactive system can be connected to the healthcare information system allowing doctors to check the accomplishment of the tasks and the progress on-line. Not only clinical information like doctor’s orders or care planning but also administrative information like appointments can be notified by the interactive system.

Finally, an important problem in healthcare is wandering and way-finding. Systems are available to detect when a patient leaves the house. These systems consist of e.g. of magnetic contacts or pressure mats at/near hall door connected to local area (family) paging. A carer may be alerted when the patient has left. Similarly, for wayfinding (at night) lighting strips and passive infra-red light switches can assist and reduce the likelihood of a fall or disorientation around the house at night.

4.2.4. The technological perspective

4.2.4.1. Introduction

From a technological perspective an AmI-like environment is based on a hardware platform and a software platform.

A typical hardware platform is made up of the following components:

- An array of sensors, which will allow monitoring the main environmental parameters;
- A network of behavioural monitoring devices, for the acquisition of user's activity patterns. For example, fixed cameras and wearable unobtrusive sensors can provide valuable information for detecting patterns of activity and estimating user habits in order to provide with personalised support;
- A network of domotic actuators, which will permit interaction and control of the smart appliances according to the users' preferences and safety;
- A computing infrastructure;
- A fixed and mobile communication network for communication inside the environment itself, connected with an external network for interpersonal communication and communication with service centres;
- Devices for the adaptation of the system's user interface. The user interface devices could be based on smart phones, PDA's or even tablet/desktop PC's, with enough processing, graphical and communication capacity to be efficient as well as adaptable depending on user preferences and capabilities.

A typical software platform should contain components allowing the following functions:

- Personalised content provision according to each user's behaviour model;
- Environment analysis and user profiling to provide adaptive interaction methods;
- Adaptation of interfaces for manual and automatic access to domotic devices;
- Identification and management of risk situations, detecting potential emergencies and generating local/remote alarms when needed.

The development of AmI-like technology can be described by using a model consisting of four layers:

- Network layer;
- Platform layer;
- User layer;
- Control layer.

4.2.4.2. The network layer

The network may be made up of already existing cables as telephone cable, TV cable and the power supply network and additional infrastructure as computer cables and low voltage cables.

Products of traditional suppliers use protocols, which allow communication between the products, remote control and central control by the resident, through a home bus. A home bus is a physical wire, a special low voltage cable, which is used to transfer signals within the house via a certain protocol. Ideally, all products of the different manufacturers should communicate via the same protocol. In practice, this is however not the case now.

In general, for control data transmission, a bit rate of some kbps is sufficient. This holds for the most of the AmI-like components (sensors, actuators, control and visualization units). However, for telecommunication purposes (above all video communication) and for complex monitoring functionalities (see next section) the bit rate exceeds to the Megabit range.

The following is an overview of several transmission media that exist:

- Wired
  - Twisted Pair
  - Power Line
  - Coaxial Cable
  - Optical Fibre
- Wireless
  - Radio Frequency
  - Infrared
  - Microwave.

Wireless technologies have clear advantages and drawbacks when applied to the smart home environment. Among the advantages, flexibility and easy installation are clearly important characteristics in this type of networks. Among the drawbacks, clearly safety and security can't reach the levels which can be obtained with wired networks, deterministic response times are not always possible and RF emissions might cause some user concern. However, it is clear that, in many cases, the advantages overcome the drawbacks and wireless network become the most feasible alternative for home automation.

Three different network families are currently used to support smart homes:

- Traditional RF home automation networks: These are usually based on relatively low frequency carriers and modulation techniques are usually quite basic, thus available bandwidth is usually very small (a few kbits/s or lower). Examples of these protocols include X10 over RF (at 200MHz) or KNX over RF (at 868MHz). Many proprietary networks based on RF remote control frequencies (433MHz) are also widely used;
- Wideband RF protocols: These protocols were originally designed for computer networks and provide relatively high bandwidth (currently up to hundreds of Mbits/s). They usually operate at 2.4GHz or 5GHz. Currently, the most popular among these type of networks is the WiFi family (IEEE 802.11a/b/g);
- Generic Low power networks: These networks have been designed very specifically for mobile device and optimized for low power usage. Bluetooth is currently the most widely used but its protocols are relatively complex and its power requirements are not suitable for devices that have to run on a small battery for years (or get the power somehow from the environment). Zigbee is a new type of very low power, low complexity network with some

built in localisation capabilities that seems to be very promising for smart home applications. Emerging standards are e.g. Low Rate Wireless Personal Area Network, LR-WPAN.

Probably in the near future most smart home networks will be based on a mix of Wi-Fi and low power networks interoperating possibly with some wired segments as well.

A major problem with smart home design is the integration and interaction among heterogeneous subsystems, which may probably not be designed to interact with each other. For example, assistive technologies are very heterogeneous when attending needs due to individual and temporal variations. Moreover, devices are usually designed by different manufacturers using different technologies for heterogeneous applications. The Design-for-All concept introduces additional complexity. It tries to avoid the simplification usually made when considering a standard user. This is supposed to help individual users, but at the same time, this lack of standardization and individual diversity and variability can increase heterogeneity in subsystem development, both in terms of applications and services, in a kind of vicious circle. As already pointed out, this problem is taken into account if design for all is interpreted in ICT as a technical approach to introduce adaptability and adaptivity in the different contexts of use and to individual capabilities.

An AmI-like environment should be able to support the interaction of heterogeneous networks, devices, services and applications. First, there is a need to interact at the internetworking level. In smart homes, if a backbone fixed infrastructure is available then a system made up of mobile devices must be connected through wireless links to the fixed wired network. For instance the backbone network may be based on the IP protocol, which has demonstrated its success in the interconnection of heterogeneous devices (a good example is the Internet). Most devices can be connected through this IP network while secondary devices (e.g. sensors) may be connected using non-IP communications. In this case a gateway can be used to interconnect IP and non- IP sub-networks. Second, interoperability should include dynamic service discovering (periodically or triggered by determined events), service description (including actions that may be performed, properties that may be useful), and service control (actions and modifications of state or attributes of a service in a sub-network from another device connected to a different sub-network).

A typical example of this interaction could be a sensor network monitoring physiological parameters (heart rate, blood pressure, sugar level). Some of the sensors may be body-worn, using a low-rate WPAN like 802.15.4. Others, may be integrated into the surroundings (chair, bed, building), probably connected through a backbone network like EIB or a WLAN like 802.11g. One of the body sensors may act as a bridge to the ambient sensor network, providing interconnectivity at the network level. But additionally, these devices may interoperate themselves at a higher level. As an example, in a health monitoring application, alarms or drug doses may be adapted using information from the ambient sensors, for instance, inferring the user activity state (e.g. driving, sleeping, exercising, or talking to someone).

An important concept within the residential environment is the definition of the Body Area Network (BAN). As already mentioned, health-related or environmental data produced by different sensors have to be made easily available to external systems. For body-worn sensors this can be achieved either by (multiple) wireless point-to-point transmission links or using the concept of integrating the sensors into the nodes of a body area network which is, in its turn, connected to a potentially global external communication infrastructure (or e.g. the Internet). The general objective is an overall system solution, where the person-connected sensors can seamlessly and securely interoperate with internal and external information systems.

In case of a BAN, the sensor nodes must be dynamically attached without expert user interaction, sharing the available BAN capabilities and resources, e.g. bandwidth. A body central unit or network access point must manage communications with the sensor units and the external world using the most appropriate network and protocol technology (that may range from GPRS/UMTS to WLAN or 4G networks). Thus a wide range of stationary and mobile applications can be realized with technologies ranging from wired and in house DECT transmission to potentially global mobile GSM and UMTS.

The BAN may also support user localisation. Within the residential environment candidate solutions can be based on the same wireless networks used for residential monitoring and BAN networking (e.g. Bluetooth, (Fraunhofer) BAN, WLAN, or Zigbee – particularly Motorola's NeuRFon self localising version). Beyond the residential environment candidate solutions will be based on GPS, GSM/UMTS, or WLAN.

4.2.4.3. The platform layer - Sensing and Monitoring

A basic function of an AmI-like environment is monitoring the environment itself and people in it.

Key elements are sensors, including personal sensors that can be integrated within an appropriate framework together with ambient sensors and distributed data sources, with the goal to provide the necessary information in a timely, secure and reliable manner and to enable continuous well-being assessment. Sensors may include:

- Pulse & heart rate;
- Breathing and blood oxygen (saturation);
- Body temperature;
- Blood pressure;
- Blood sugar;
- Walking motion;
- Acceleration (for falls);
- Ambient temperature and humidity;
- Gas sensors (CO, CO2, …);
- Location (using GPS, cellular, or LR-WPAN based location systems);
- User activated sensor.

Particular important are the following issues:

- Adoption of solutions that enable "invisible" and seamless body sensors;
- Building technologies feasible for miniaturization and attachable to body, clothes and garments, especially electronic circuitry built on flexible materials;
- Adoption of technologies with a very low power;
- Novel power supply technologies, e.g. body generated power supply;
- Low power mobile sensors, e.g. ECG, cardiovascular flow, heart rate, blood gases (oxygen saturation), skin resistance, skin temperature.

The use of sensors is fundamental for the development of innovative living spaces that e.g. allow people to stay in their home, moving within an integrated ICT service framework, and grants them an enhanced patient monitoring and an easy interaction with the external world.

Wireless sensors are an emerging technology for many reasons as low-cost and their ability to monitor a wide range of physical signals and data. In the last years a fast progress has occurred in energy efficiency, dimension reduction, networking, data management and security. A great effort has been devoted to the development of sensors for health monitoring, as to be wearable or easily transportable. As an example, today wireless sensors are available for the monitoring of: temperature, blood pressure, glucose, toxins, UV dose, drug dispensing, but also EEG, ECG and EMG; moreover, accelerometers, gyroscopes and electro-myogram (AMG) sensors for stroke patient monitoring can be found.

According to the AmI paradigm, in the future sensors are supposed be located in objects and to be wearable, concurring to the creations of environments sensitive to the presence of people and responsive to their needs. This perspective has originated a great effort in research and industrial applications for the implementation of sensor networks, composed of a large number of sensor nodes, which are densely deployed in the environment. The main idea is that the network must not be pre-organised, but it must be able to self-organize. The intelligence in the network nodes is supposed to pre-process the data. As a consequence, new wireless communication technologies have been developed (as for example Zigbee) in order to optimise the performance of a sensor network. These new developments are multidisciplinary and involve many technological fields, as hardware and system design, networking, distributed algorithms, programming models, data management, security and services.

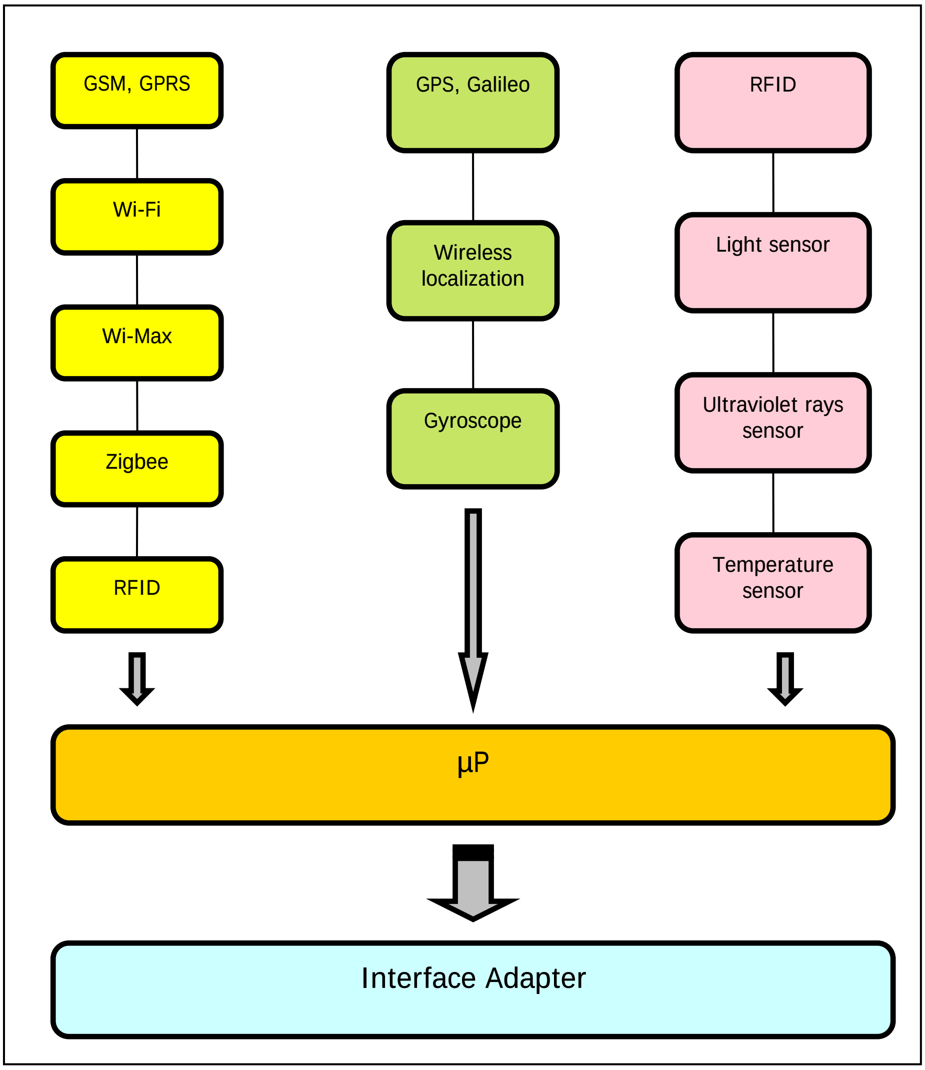


Figure 4.3: General scheme of the basic mobile terminal.

The new concept of the "virtual sensors" can also be introduced in connection with networking and intelligence. A virtual sensor is a generalised sensor obtained through the integration and data fusion of data coming from real sensors in order to detect or describe "complex" phenomena. A typical example of a virtual sensor could be designed to measure the anxiety or stress status of a user. In principle, virtual sensors can implement complete previsional models, by implementing very complex operators, to extract knowledge from the environment.

4.2.4.4. The user layer

4.2.4.4.1. The personal communicator

In all ISTAG scenarios, where some AmI features are represented, people are equipped with a personal communicator, which is the communication system connecting the individual users with the environment. A first version of a personal communicator with many of the functions needed for interacting with an AmI like environment is possible with the integration of available technology.

As an example, a system able to evolve from simple communication tasks to a complete interaction with the environment can be built by combining the following three main elements (Benelli, 2006, personal communication):

- a Basic Mobile Terminal (BMT, Figure 4.3), allowing the implementation of a minimum set of functionalities and services in any context;
- a Wireless Sensor System (WSS, Figure 4.4), designed to monitor some parameter of the user (health and or emotional status) through wearable or portable sensors;
- an Extended Mobile Terminal (EMT, Figure 4.5), providing the user with additional functionalities or services with respect to BMT, on the basis of user needs as well as of the surrounding characteristics of the environment.

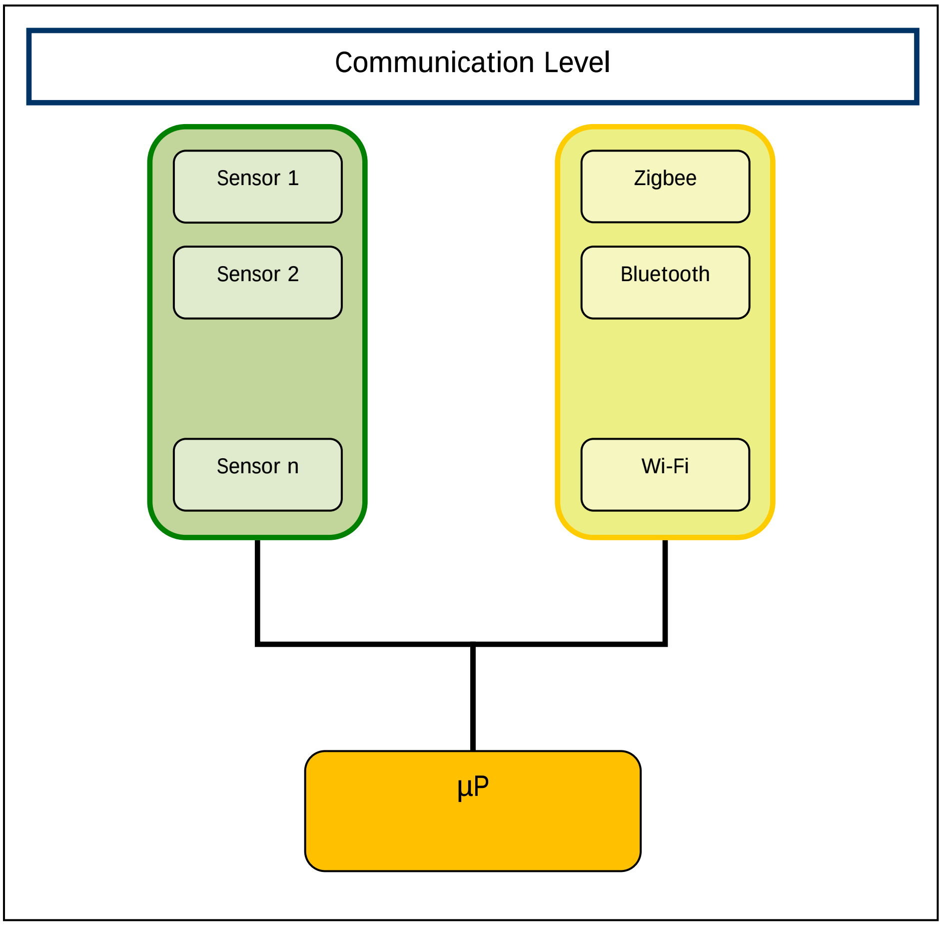


Figure 4.4: General architecture of WSS

The BMT is designed to grant support and assistance to users anywhere and anytime. It must be robust enough to guarantee communication in any context, interaction with the surrounding environment, and user's localisation when moving indoor and outdoor, to allow assistance if needed. It is based on mainstream technologies and can be a simple (i.e. not more complex that a modern smart telephone) device, usable by all. The user interface can be adapted to user needs and abilities. Figure 4.3 presents the main components of the BMT.

The BMT is composed of the following main functional elements:

- a Wireless Communication Component (WCC), supporting different wireless technologies to ensure communication capabilities and service availability anywhere and anytime. Communication is intended to be with people and with the surrounding environment;
- a Localisation Level Component (LLC) enabling navigation and user localisation both in outdoor and in indoor environments. The LLC is based on the GPS or GALILEO positioning systems; where they are not available (absence of connections or indoor environment) or their precision is not enough, localisation may be realised through the wireless infrastructure;
- a Sensor Level Component (SLC), where basic sensors are available;
- a Microprocessor (µP) controlling and managing all the functionalities of BMT;
- an Interface Adapter (IA) supporting the adaptation of interface to the user needs, but also to the environment and context of use.

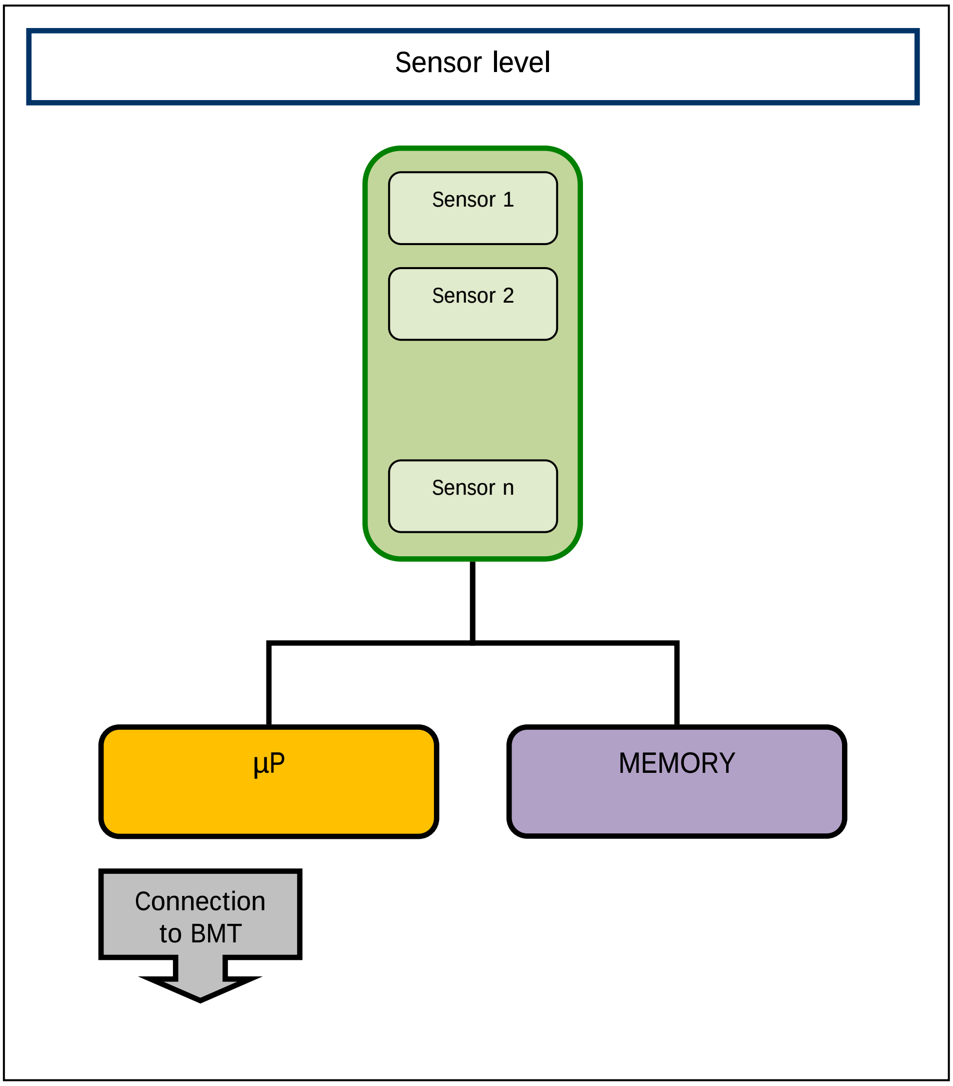


Figure 4.5: General architecture of EMT

The BMT (Figure 4.3) allows users to be always connected and able to communicate. The other two optional components of the mobile terminal provide additional functionalities to support users in their activities. The WSS is a portable (generally wearable) terminal designed to monitor the health or emotional status of the user by measuring a set of relevant parameters (Figure 4.4). Each user can own and use a different WSS depending on the individual needs.

The WSS is divided in two main parts: (i) the communication level; (ii) the sensor level. The number of sensors and their characteristics are chosen according to user needs. Data measured by the sensors are transmitted to the basic communication terminal through the communication level. The WSS is based on the integration of wireless sensor network technologies.

The third component of the mobile terminal, the EMT (Figure 4.5), is designed to enhance interaction and communication, supporting communication and monitoring with additional intelligence. It is an optional component, composed by specialised sensors and additional processing capabilities.

Even if perfectly possible with the integration of available technology, the personal communicator can evolve to be a complex system. However a foreseen trend with the emergence of the AmI approach is that most of the intelligence and facilities available in the terminal will migrate in the environment, thus allowing the use of additional intelligence and reducing the weight and power consumption of the terminal.

4.2.4.4.2. User interaction

A smart environment may provide an extremely large number of choices and some of them may be quite complex. An interface that directly offers all the possibilities to the user may result cumbersome and complex. On the contrary, the user interface should act as an intelligent intermediary between the complex system and the user. This is the reason why Artificial Intelligence methods and techniques are starting to be used for the development of adaptive intelligent interfaces. It must be considered that accessibility and usability represent the dimensions according to which the success or failure of a technological application or service can be determined and assessed.

Intelligent interfaces are supposed to be able to adapt to the user physical, sensorial and cognitive capabilities, some of which may be restricted due to aging or impairments and/or may change along the day, due e.g. fatigue, and changes in motivation. To this end, the interface must have a model of the users and be able to make assumptions about their actual situation from the current value of a number of parameters as measured by sensors and/or made available by the evolving interaction behaviour. However, adaptive intelligent interfaces can also have problems; the most important one is the possibility of errors in adaptation. The adoption of erroneous assumptions about the user may make interaction impossible, by e.g. interaction modalities that they are not able to use due their personal activity limitations or contextual factors.

Another important characteristic of the human interfaces for smart environments is their spatial dependency. The interaction model is not any more based on the assumption of a person interacting with a computer or a terminal. Therefore, many features and possible effects of interaction depend on the position of the user. For instance, a simple command as "switch on the lights" must be differently interpreted according to the place where is has been given. Provided that the user is located with enough precision, the interface needs a spatial model to be able to decide what the lights to be switched on are. In addition, the services that can be offered to the user are restricted to the ones present in its current location.

The problem is also made more complex by the fact that the advent of smart environments is part of the fusion that is occurring overall in technology, between telecommunications, information technologies and media industry. Through the exploitation of advances in technology, the smart environments allow the convergence of different possible activities connected to independent living, work, education, health care, leisure in the same physical environment. For example, within the Ambient Assisted Living context it is argued that “Ambient Assisted Living aims to prolong the time people can live in a decent way in their home by increasing their autonomy and self-confidence, the discharge of monotonous everyday activities, to monitor and care for the elderly or ill person, to enhance the security and to save resources" (IST results, 2006). Therefore, possible interactions must be general enough to accommodate all the different possible activities.

On the usability side, projects so far seem to build on an interface-based interaction model, which basically consists of providing the user with simple interfaces ranging from classic GUIs to vocal commands. That is, the potential lying in the conjunction of Ambient Intelligence and adaptivity substantially remains unexploited. On the contrary, users as, for example, people with activity limitations require using the flexibility of the adaptive strategies in order to meet the specific conditions of the users. It should be considered that users affected by visual, hearing or motion impairments often represent a significant part of the elderly population; therefore the issues of accessibility should be incorporated in the deployment of AmI-like environments. Multimodal interfaces and redundancy could be useful for helping people with activity limitations in carrying out their tasks.

An interesting approach could be based on the introduction of the Ambient User Interfaces (AmUIs) paradigm. In contrast to typical graphical user interfaces (GUIs), which are always instantiated on a computer screen, AmUIs can take advantage of the available Ambient Intelligence Infrastructure, in order to support interaction that is tailored to the current needs and characteristics of a particular user and context of use. Thus, they could be multimodal and distributed in space (e.g., employ the TV screen and stereo speakers to provide output, and get input through both speech and gestures). These interfaces could allow the interaction between humans and the ambient technological environment in an efficient, effective and intuitive way which also guarantees their well-being, privacy and safety, while on the other hand they could creatively combine the available, dispersed computing devices in order to provide useful, added-value, services. This could support seamless, high-quality, unobtrusive, and fault-tolerant user interaction, by creating software frameworks for developing and orchestrating ambient interactions, and by designing and developing useful ambient interactive systems that cater in the best possible way for the real needs of their users.

Therefore Ambient User Interfaces (AmUIs) should be able to:

- take advantage of the available Ambient Intelligence Infrastructure, in order to support seamless, high-quality, unobtrusive, and fault-tolerant interaction that is tailored to the current needs and characteristics of a particular user and context of use;
- allow multimodal interaction distributed in space (e.g., employ the TV screen and stereo speakers to provide output, and get input through both speech and gestures);
- use behaviour patterns extracted from the interaction itself in a proactive way (e.g. compare user's routine with an optimal routine and suggest activities), in preventive way (checking the status of appliances and monitoring actions left unfinished such as cooking in order to prevent accidents) and in assisting way (e.g. by analyzing and extracting the user's path patterns outside the house, the system could make suggestions and issue reminders).

4.2.4.5. The control layer - Intelligence in the environment

It has been written in one of the previous sections that the minimum characteristics for an AmI environment to be useful is that it must contain intelligent objects, that the objects must be able to communicate among themselves, and that the environment must be connected, i.e. it must have internal and external networks, allowing interactive and remote control of systems, as well as access to services and information, both within and beyond the environment itself. However it is clear from the discussions in the chapter that this is not enough. The environment cannot be useful if a "purposeful" communication and control of its single parts (objects and available services) is not available. This means that an "intelligent" control must be available and the usefulness of the environment increases when the available intelligence exists.

So far most of the control systems available in the AmI like environments are essentially deterministic systems, which take decisions about actions on the basis of physical measurements and with the support of pre-determined algorithms. The real intelligence lies with people in alarm and control services, in health care units, and in the environment itself. A typical rule may be: if the temperature is higher than 37 °C, then call the health care service. It is obvious that it is not advisable to aim at completely automatic systems, because even if they would be feasible, contact with other human being is more important than any technical support in many situations. However, the possibility exists of moving toward the final goal of transforming them in learning and attentive environments.

4.3. Technological development

Recently an interesting report has been published by the American National Council on Disability (National Council on Disability, 2006), where some recent technological developments are described and their possible impact on Assistive Technology is discussed. The main findings in the document are summarised in this section extending the analysis, when appropriate, to the AmI environment.

4.3.1. Computing power

One of the main trends pointed out in the document is that the computational power is ever-increasing while the size, power consumption and cost of the corresponding components are decreasing. Even if the Kurzweil prediction that by 2020, $1,000 will purchase the computational power of the human brain (Kurzweil, 2001) may probably be disputed, it is clear that the “intelligence” of computer based systems will grow in the near future. The cost of computing drops by a factor of 10 approximately every 4-5 years. It is not uncommon to find children’s video games that have more computing power than supercomputers of just 10-15 years earlier. Obviously, computing power does not mean necessarily more intelligence, but it is surely a prerequisite to support artificial intelligence applications.

Considering dimensions, personal digital assistants have shrunk from the size of paperback books to credit card size, and now to a function that runs in the back of a cell phone. Cell phones have shrunk from something just under the size and weight of a brick to cigarette-lighter size, most of which is occupied by the battery.

Nanotechnology is also developing very fast. It is very likely that this will have impact on many different aspects of technology, particularly in the sector of sensors, which will become not only wearable but also implantable and able to navigate through the human body.

4.3.2. New Interfaces

Advances in interface technology are creating new opportunities for better assistive technologies, more accessible mainstream technologies, and entirely new concepts for controlling both.

Using a projector and camera, keyboards, displays and control panels can be projected onto a tabletop, a wall or any other flat surface (Figure 4.6). When people touch the “buttons” in such an image, the camera tracks movements, and the buttons or keys operate as if they really existed. Alternatively, it has been demonstrated that it is possible to project an image which floats in space in front of a person and is seen only the person using glasses or goggle-based system. It is also possible to project the image directly onto the retina. A gesture recognition system can be used to operate the controls that float along the display. Motion sensors can cause the displays to move with the user's head, or stay stationary. It is also possible to project images to overlay them with what a person is seeing in reality, to create an “augmented reality.” For example, a traveller, moving in a city in a foreign country, by wearing a pair of glasses could see a translation of a street sign (in her/his native language) projected over the top of the sign.

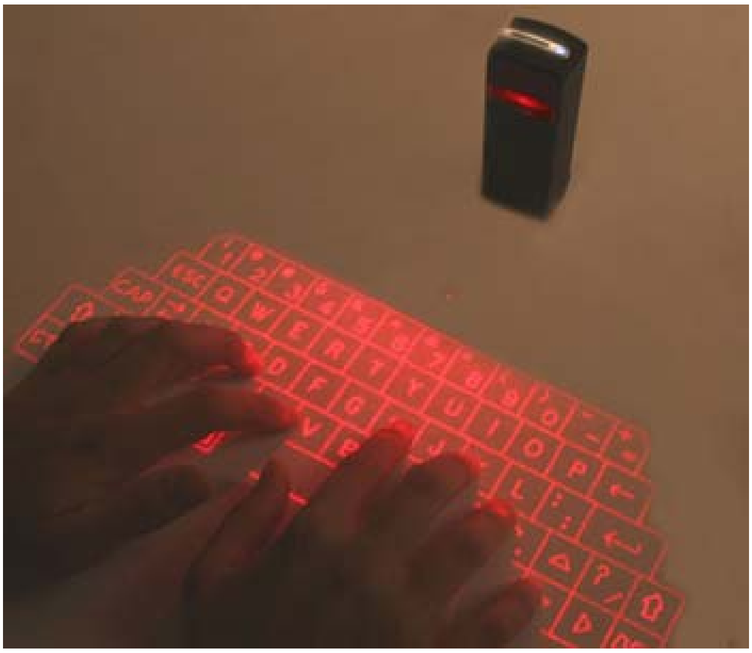


Figure 4.6: A laser beam is used to generate a full-size perfectly operating laser keyboard. Source: I-Tech Virtual Laser Keyboard.

Finally, research is taking place on ultra high resolution displays with a target of being able to display images that appear with the same fidelity as reality (virtual reality). Introducing three-dimensional viewing and displays that work in 360 degrees, researchers have a goal of eventually creating walls or environments that are indistinguishable from reality.

Voice technology is developing hands-free operation and voice control. There are already hands-free telephones. New phase-array microphones have been developed that can pick up a single person’s voice and cancel out surrounding sounds, allowing communication and voice control in noisy environments.

There are cameras that can self-adjust to track a user's face, allowing face-to face communication for those who cannot reach out to adjust cameras. Rudimentary speech recognition is available on a $3 chip and speech recognition within a limited topic domain is commonly used. IBM has a “superhuman speech recognition project, the goal of which is to create technology that can recognize speech better than humans can (Howard-Spink, 2002).

The cost to build speech output into products has reduced to the point where speech can be provided on almost anything. Operating systems today have free speech synthesizers built into them or available for them. Recently a standard cell phone that had been on the market for a year received a software-only upgrade and became a talking cell phone, with not only digitized speech talking menus, but also with text-to-speech capability for Short Message Service (SMS) messages.

Moreover, there is a rapid diversification in the ways people communicate. Video conferencing allows simultaneous text, visual, and voice communications. Chat and other text technologies are adding voice and video capabilities. In addition, the technology to cross-translate between modalities is maturing. The ability to have individuals talking on one end and reading on the other is already available using human agents in the network. In the future, the ability to translate between sensory modalities may become common for all users.

Direct control from the brain is slowly becoming a reality**.** External electrodes in the form of a band or cap are available as commercial products for elementary control directly from the brain. Research involving electrode arrays which are both external and embedded in the brain have demonstrated the ability to interface directly with the brain to allow rudimentary control of computers, communicators, manipulators, and environmental controls.

Finally, it can be considered that when products are controlled by microprocessor, they can be programmed to operate in different ways at different times. The use of more powerful processors, with more memory, is resulting in the emergence of new devices that can be controlled in many different ways and can be changed to meet user preferences or needs.

4.3.3. The interconnected world

New advances will soon enable people to be connected to communication and information networks no matter where they are.

There are already wireless headsets, computer networks, music players, and sensors. New technologies, such as ZigBee, will allow for devices that are very small, wirelessly connected, and draw very little power.

High speed wireless networks are also evolving, and costs are dropping. No wires will be needed between TV sets, video recorders, or anything else (except sometimes the wall, for power, though Philips has recently introduced “PowerPad”, a tray on which electronic instruments can be simply put on, to have their battery recharged without the need of plugging any power wire into the wall (see Aarts, 2006). A person in a power wheelchair could have an on-chair controller connected to everything in the house, and yet still be completely mobile. New universal remote console standards have been developed that would allow products to be controlled from other devices (see Zimmermann et al., 2004). Products implementing these standards could be controlled from interfaces other than the ones on the product. A thermostat with a touch screen interface, or a stove with flat buttons, for example, could be controlled from a cell phone via speech, or from a small portable Braille device.

Computing power will be available in the network. Wherever a person is, he or she will be able to use whatever display is convenient, e.g., on the wall or in a pocket, to access any information, carry out computing activities, view movies, listen to music, etc. Instead of making each product accessible, things would exist as services and capabilities, which could be accessed through a person’s preferred interface.

GPS (Global Positioning System) devices enable people to determine their position when outside, and are already small enough to fit into cell phones and large wristwatches. Other technologies, such as RFID (Radio Frequency Identification) and devices that send signals embedded in the light emitted from overhead light fixtures, are being explored to provide precise location information where GPS does not work. GPS Systems to tell the wearers where they are and which direction they are going may also be used in shoes.

Tiny chips can be embedded into almost anything to give it a digital signature. RFID chips are now small enough that they are being embedded inside money in Japan.

Today jackets with built-in music players, with speakers and microphones in the collar, are available in the market, as well as keyboards that fold up, and circuitry that is woven into shirts and other clothing. Glasses and shoes with a built-in computer that can detect objects within close proximity through echo location and then send a vibrating warning signal to the wearer are also available.

Finally a lot of implantable technology is available. There are cochlear implants to provide hearing. Heart and brain pacemakers are common. Increasing miniaturization will allow all types of circuits to be embedded in humans. In addition, research is continuing not only on biocompatible materials, but also on biological “electronics”.

4.3.4. Services on demand

With the ability to be connected everywhere, it is possible to seek assistance at any time. A person who doesn’t understand how to operate something can instantly involve a friend, colleague, or professional assistant, who can see what he or she is looking at and help. Someone who needs mobility assistance could travel independently, yet have someone available at the touch of a button.

These assistants could help think something through, see how to get past an obstacle, listen for something, translate something, or provide any other type of assistance, and then “disappear” immediately. From this perspective, it is interesting to observe that technology can be used to enhance human support. This can be invaluable for the psychological welfare of people.

Possibly one of the most revolutionary advances in information and communication technologies has been the development of the World Wide Web. Although the Internet had been around for a relatively long time by the 1990s Web technologies allowed it to be approachable and usable by people in a way not previously possible. It has not only given people new ways of doing things, but has fostered the development of entirely new social, commercial, and educational concepts. It also has allowed for virtual “places” that exist only in cyberspace. This includes virtual environments, virtual stores, virtual community centres, and complete virtual communities. E-travel is allowing people to go to places and see things that once were only possible through books or documentaries. Electronic re-creation can allow people to explore real places, as if they were there, and at their own speed. They could wander a famous museum, for example. The Web also provides an array of products and services that is unmatched in physical stores in most localities.

4.3.5. Image processing and pattern recognition

If we consider AmI like environments, some emerging technologies that could improve their functionalities can be considered. One possibility is the use of emerging unobtrusive activity monitoring framework based on computer vision technology, based on the assumptions that:

- a set of low-level and medium-level attributes associated with user behaviour may be captured using a network of cameras;
- higher-level inference of user activity can be performed in a higher abstraction level, fusing information from different sources.

Such systems are supposed to allow:

- Distinguish a person from other persons or objects in the same environment, based on a combination of measurements of simple features such as user height or silhouette shape, walking pattern, and face patterns;
- Visual localization of humans and objects in the environment irrespective of the variability of environmental conditions (e.g. changes of illumination, single or multiple subjects, still or motion, etc), using algorithms able to automatically learn and model the appearance of the environment;
- Discovering elementary spatio-temporal patterns, such as sitting up/down, walking from one place to another, grasping an object etc., using probabilistic model-based as well as example-based machine learning techniques;
- tracking over time of the localized objects and computation of motion attributes computed from their measurements of velocity, acceleration, trajectory curvature, rhythm or periodicity.

Visual information can be a significant source of input in monitoring the activities of people and their environment, even if prior to detecting objects and activities and to recognizing objects and events, a considerable amount of image and video processing is required to extract the spatiotemporal visual features that will finally facilitate the above detection and recognition processes. Although the extraction of primitive visual features, such as edges, lines, corners, texture, and motion, has been studied for long time in the discipline of Computer Vision, recent advances in the field introduced novel visual features and more robust ways of extracting them. Utilization of state-of-the-art in the measurement of visual features will facilitate increased precision, which in turn, is critical for the robust detection of events and localization of objects.

4.3.6. Dealing with emotions

Although research on the neurophysiologic and psychological components of emotion has been active for a very long time (e.g. Davidson and al., 2000; J. T. Cacioppo, L.G. Tassinary, 1990; Rolls, 2000; Davidson, 2003; Aftanas et al., 2004; Grandjean et al., 2005), it is only more recently that work has started on automatically appraising emotional status on the basis of signal and image processing techniques. Significant work has been achieved on using facial images, possibly coupled with voice analysis, to infer the emotions of a person (e.g. Cowie et al., 2001). These approaches however suffer from the drawback that facial expressions and to some extent voice can be purposely altered to mask one's emotion. In recent years, fostered in part by the advances in seamless and personalized human-machine interaction, as well as by the increasing need for sophisticated security apparatus (e.g. lie detectors, biometrics), there has been a growing interest in using physiological signals for emotion recognition. Typical signals that can be used are electro-encephalograms (EEG), electromyograms (EMG), electro-cardiograms (ECG), blood pressure (to measure heart rate), galvanic skin resistance (GSR) and body temperature.

Studies report on the use of out-of-the-shelf physiological sensors to categorize emotions by means of signal processing and classification techniques (Lisetti and Nasoz, 2004). Despite the richness of their content, EEGs are rarely used in such settings due to the current cumbersomeness, cost, complicated setup of EEG equipments. Even if used, it usually is by themselves (Bostanov, 2003), without coupling with other physiological signals (Takahashi, 2005). The use of EEGs in addition to other physiological signals seems however justified, because of the richness of the information they carry, as well as because of the progress in the development of dry EEG electrodes; these, coupled with wireless communication, should allow in the coming years for non-invasive and easy to affix EEG sensors.

A current challenge in emotion recognition from physiological signals lies in the categorization of emotions. The first goal is to be able to quantify two components of emotion based on physiological recordings: valence (i.e. positive emotion vs. negative emotion) and arousal (calm emotion vs. excited emotion). Most current theories on emotion assume that valence and arousal define a 2D space in which higher level emotions can be located. Some are known as “basic” emotions such as fear, joy, sadness, etc (Ekman et al., 1987). Some are more complex, such as well-being, solitude/loneliness, anxiety, apathy, boredom, awareness, fatigue. For instance, well-being could possibly be tied to joy, solitude to sadness, anxiety to fear, apathy and fatigue to absence of reaction. Another challenge is to be able to detect such emotions in ecological situations, in opposition to settings where a subject is presented with controlled stimuli at precise instants and his/her reactions are recorded.

4.3.7. Artificial intelligence

Artificial intelligence principles and techniques are starting to reach applications in different environments.

One of them is natural language processing**.** The capability of technology to process human speech continues to evolve. Although full, open topic natural language processing is not yet available, natural language processing for constrained topics is being used on the telephone and may soon allow people to talk successfully to machines.

Artificial intelligent agents are a second very important sector of fast developing applications**.** Websites are available that allow users to text chat with a virtual person, who helps them find information on the site. Research on task modelling, artificial intelligence, and natural language are targeted toward creating agents users can interact with, helping them find information, operate controls, etc. Often the subject of science fiction, simple forms of intelligent agents are reaching the point of becoming a reality in the home.

In an AmI-like environment intelligent agents could undertake proactive action in order to protect users from danger and to prevent them from hazardous action, by alerting e.g. a cognitive-impaired person. Moreover the proactive intervention can aim to ensure the consistency in performing “good” activities, to detect unintended “bad” habits, and to suggest alternatives. The proactive agent could warn the user in case of negligence to carry out a specific scheduled task (e.g. treatment). Additionally, in case there is no response from the user, the agent could act based on specific pre-programmed (at least in the short term) actions. Behaviour of the proactive intelligent agent will be based on the user’s behaviour that is tracked and interpreted according to the activity.

In combination with the virtual companion, the proactive agent can also provide an innovative and user-friendly interface in the form of a customizable avatar. Therefore a user interaction support module can be designed to support natural interaction with the user and also to provide user-friendly presentation mechanisms through the use of a virtual companion. The user interface will seamlessly integrate communication with other persons and service providers as well as with the local environment. Content will be presented to each user in a personalised manner, adapted according to user habits, personal profile or environment features.

4.3.8. Integrated approaches

The support of users should derive from the understanding of different concurring factors: behavioural status information (which can be captured mainly by the audio and video signals), environment related information (to provide awareness of the physical environment of the user and possible interactions with other persons), functional information of smart appliances in the house (interaction with domotics) and the interactions of the above.

In order to make this support possible it is necessary to integrate different knowledge and technologies. A (rather incomplete) list of objectives to reach e.g. in the example case of older people with cognitive limitations is the following:

- To understand relevant aspects of cognitive capability changes in the older population, including, in particular, human memory, with emphasis on the retrospective ability to recall and recognize past events as well as prospective memory, i.e. the ability to remember and execute intended activities at a particular time in the future;
- To develop a set of agent-like tools for enhancing inclusion of older and cognitive-impaired persons in many aspects of real life (increase autonomy in home, shopping, navigation, etc.);
- To integrate existing state-of-the-art sensors, domotics and networking technologies in a transparent and unobtrusive infrastructure including monitoring and interaction modules;
- To develop appropriate gateways to key assistive technologies (such as domotics, emergency management, computer and content accessibility, etc.) and communication services;
- To create an Artificial Intelligence framework that will allow the classification and recognition of the user’s Activities of Daily Living in order to allow for the detection of unusual patterns that may lead to accidents. This framework must also allow the proactive operation of the system that will stimulate the user’s physical and mental activity;
- To include appropriate and innovative user interfaces for the cognitive impaired and older users;
- To develop an “activity reminder” framework that will help people with memory-associated cognitive disabilities efficiently remember essential everyday tasks thus restoring at some level the human memory capabilities. This can be done autonomously via analysis of extracted and recorded patterns of activity and, concurrently, via the manual insertion of essential tasks (by third party supportive users like doctors, family and nurses) that constitute the user’s daily routine;
- To develop multimodal signal (video, speech, gestures etc.) analysis techniques for the detection and understanding of patterns of activities, including human presence and activity

recognition, indoors movement monitoring and non-verbal communication cues (body language, facial expressions, speech intonation patterns etc.).

4.4. Possible impact of technological developments on AT and AmI

According to (National Council on Disability, 2006), foreseen short – medium time technological developments can have an important impact on the situation of people with activity limitations both from the perspective of improving the quality of Assistive Technology and for leading to the implementation of more accessible mainstream products. In the following paragraphs some of the possibilities considered in the document are summarised and some examples of future improvements of AmI-like environments are given.

First of all, the reduction of size and power consumption of devices for access to information and interpersonal communication can offer important opportunities. As a matter of fact, rapid advances are being made every year in reducing the size and increasing the power of electronic devices. This is leading to smaller, less expensive, and more “intelligent” products and provides a greater opportunity to create assistive technologies that previously would have been too big or required too much power.

A second very important contribution is given by the reduction of cost of technology. One concern regarding the use of personal technologies by people with cognitive disabilities is the risk that the products will be lost or stolen. With core functions being implemented as services on the network, and technology costs dropping, portable devices that could offer AT functions for people with cognitive disabilities will soon be so inexpensive that they can be easily replaced if lost. To reach these price points, however, AT devices will have to be based on mainstream devices. As an example, the possibilities offered by new mainstream devices based on PDAs and integrating a telephone (GSM or in perspective UMTS) and a GPS antenna, can be considered: they offer communication, localisation, availability and access to information, and “intelligence” (increasing in time). This intelligence can be used to offer additional functionalities, including support to the users e.g. in terms of adaptations of the interface, guidance in the environment, support to memory.

This will be favoured by the improvement of speech and natural language-enabled technologies and intelligent agent software embedded in mainstream products. For example, speech synthesis is no longer a significant cost factor and can be added with little or no hardware costs. Network-based services can further reduce costs by putting the intelligence and memory in the network and allowing a new device to pick up where the last one left off.

Although the cost of technologies is continually decreasing, some assistive technologies may in fact be expensive. The cost for some types of specialized technology could run to € 10,000 or more (much more if it needs to be surgically implanted). The cost for failing to make technology accessible to people with disabilities, however, can be even higher. The 2005 average cost of nursing home care in the USA, for example, was over $60,000 a year for a semi-private room (National Council on Disability, 2006). That leaves quite a margin for technologies that would delay entry into a nursing home by even 6 months or that could allow a person to live in a semi-dependent living situation.

The trend toward wearable technologies can also be helpful for meeting the need for people with activity limitations to carry devices, leaving their hands free for other tasks. This will be particularly helpful for people who use canes, walkers, and service animals, and generally already have at least one hand in use. People who have a cognitive disability that makes it difficult to remember such devices, and who might therefore leave them behind, will also benefit from wearable technologies. Very sophisticated communication and health monitoring technologies can now be worn on the wrist or woven into clothes. The trend is toward less expensive products with more functions.

These developments can potentially make the world more usable by people with activity limitations, but advances in technology can also help enhance the overall abilities of people to better interact with the world. Cochlear implants have been available for some time, as have prosthetic limbs. Research is progressing on artificial retinas. Advances in electronic imaging, robotics, and computer processing promise advances in the enhancement of human abilities to access the world. The new imaging and processing technologies also open the door for providing individuals with new and different ways to mitigate their limitations. For example, an artificial eye might be able to provide enough vision for basic mobility, but not enough to read 10-point type. The same artificial eye, however, could have a processor and optical character recognition capability built in that could read any text the person looked at using synthetic voice. Using network connectivity and intelligence in the environment the text could also be translated, enhanced, or explained if needed.

Direct access is the ability of a user to operate a product without the need for Assistive Technology. Building direct access into products is generally the most effective, least stigmatizing, most available, and affordable method of providing access. For people with multiple and severe disabilities, it may sometimes be not practical to build direct access into mainstream products. The types of interfaces required, such as dynamic Braille displays, electrodes, sensors mounted on the wheelchair, etc., typically cannot be included as standard parts for mainstream products. For these people, the best approach may be to access mainstream products by controlling them with special AT interfaces via a standard interconnection/control method. This would require these users to have a special AT interface device.

In addition to supporting people in overcoming some of their activity limitations, technical developments can help in producing more accessible mainstream products, if accessibility is included among the design specifications and the capacities of all potential users are taken into account in defining the accessibility targets. For example, it can be considered that almost everything today, including TV remote controls, cell phones, alarm clocks, microwaves, ovens, washers, and thermostats, is being controlled by one or more microcomputers. Therefore, it is now possible to design products that will follow different instructions and behave differently for different users. Many products can already be adjusted to accommodate possible limitations of users. Additional possibilities could be offered using technology, particularly computing power built in the devices in order to simplify their use. The effort should be to offer users more complex functionalities, but with simpler interfaces. An example is the use of *unrestricted* voice recognition and natural language processing that will be made available in the future, while the ability to use these in practical ways in limited domains (e.g., controlling household appliances) is already emerging. This will be an important advance for individuals with cognitive disabilities or people who, for any reason, are unable to effectively use knobs, buttons, and menus on products.

Some of the above examples of new possibilities offered to users are based on the fact that computing power is available in any environment and that, waiting for a complete emergence of the Ambient Intelligence paradigm, people needing a special interface to approach a device are able to link to it and operate it from their own interface. This needs the availability of a complete wired and/or wireless interconnectivity. For example, the use of a universal remote standard console would give access to almost any device in the home, work, or community, from a thermostat to office equipment. Universal remote controllers could include any of the current and future types of AT, including devices with Braille displays, sip and puff controls, natural language interfaces, or some day, even direct-brain interfaces.

The trend toward multi-modal communication (voice, video, chat) using the same device, can be very important for individuals with sensory limitations, especially individuals who are deaf, hard-of-hearing, deaf-blind, or speech-impaired. If “any-modality” communication can be implemented in mainstream technologies with the same ubiquity as captions are on televisions, individuals who are deaf or hard of hearing will be able to use almost any phone. People who are deaf can use text mode. Those who are deaf but can speak can use speech to talk, and then read the display on the phone for text coming back to them. People who are hard of hearing can listen, and have text displayed in parallel, or when they cannot understand. Individuals who sign can use sign language, and individuals with cognitive disabilities can use gestures and visual cues to facilitate communication. If the evolving translation capabilities are added, services in the network can change communication modality as needed.

As a further example of possible short-medium time improvements connected to the use of technology, the potential impact of emerging image processing and pattern recognition technology can be considered. Several functions can be performed using this technology in AmI-like environment, if enough computer power is available to implement the required complex algorithms and enough intelligence allows the extraction and organisation of extracted data.

A first very important function is the localization of humans and objects in the monitored environment. Even if, due to the possible moderate quality of the sources and the distance of the cameras from the targets it may be difficult to perform object recognition e.g. identify the user by face recognition, object localization can be based on detecting visual differences on the images. The main challenge is to guarantee a high level of robustness despite variability of environmental conditions (e.g. changes of illumination, single or multiple subjects, stillness or motion etc). This can be addressed by the development of algorithms with the ability to automatically learn from and model the appearance of the environment from its variations during the day, integrating information over time and from different sources (several cameras sharing the same environment) and compensate for such variations during the detection of the targets.

A further task of the vision modules is to distinguish the targeted older person from other persons or objects in the same environment. This is essential in scenarios where the user has social contact with other persons in the home or when more than one older people are living in the same home. When using low-cost cameras from a distance, identification can be based on a combination of measurements of simple features such as user height or silhouette shape, walking pattern, and face patterns if the user is close enough to a camera thus allowing sufficient accuracy. An essential part of the system is self-training thus requiring no cooperative user enrolment.

Localized objects can be subsequently tracked over time, and motion attributes will be computed from their trajectories such as velocity, acceleration, trajectory curvature, rhythm or periodicity. Movements of the crucial points of the human body (hands, feet, head and centre of gravity) can be analyzed in order to detect simple actions such as walking, bending down or displacing an object.

In perspective, sensor fusion should also include emotion interpretation. Detection of the emotional state of the user, also taking into account the initial emotional state, possibly involving psychological research on the user's emotional type can be helpful to see if the person feels comfortable, for instance, or if s/he is happy, or upset, or subjected to depression.

Using the previous approach passive alarm and control systems and services can be set up able to monitor the activity of the different persons even in the same environment, to draw inferences about the type and quality of activities (e.g. movement) in order to anticipate possible difficulties, to draw conclusions about their emotional status. This would be an important contribution to the implementations of living environments able to offer increased possibilities of independent living.

Obviously the above results are obtainable only if sufficient computing power is made available for real-time processing of image frames (and this will be available in the near future). Added to this intelligence should be available for the efficient fusion of all available data and for reasoning about the situation and the actions to be performed. Not all necessary intelligence needs to be available as "artificial intelligence". Carers must be available when necessary, and, due to the diffusion of broad-band connections, human beings can be in the decision chain even if not physically present.

Intelligence can also contribute in applications not connected with the AmI-like approach. For example, information throughout the environment is presented at a wide range of levels of complexity, which can create difficulties for people with cognitive limitations. As researchers master the ability to create technology that can translate between languages, including translation between more complex and simpler languages, they are developing many of the tools needed to translate between different levels of complexity and vocabularies within the same language. These language translation technologies could be adapted to translate between sign languages and spoken languages.

Impact is also possible in Assistive Technology. With rapidly shrinking technologies, it will not be long before it is possible to implant imaging devices into contact lenses, so that even individuals with good vision could have enhanced vision, automated or human-based cuing on demand, text that could be read aloud by looking at it, etc. Such capabilities could be very important to individuals with language, learning, or cognitive disabilities. Already, there are cameras that will read text when it is photographed, and concept glasses with built-in cameras that perform face recognition of whomever a person looks at. With the use of heuristics with increasing computing power, it is also possible to begin thinking about assistive technologies that would take in a complex display of information (e.g., all of the text visible down the corridor at a shopping mall) and present it to a person in a coherent way.

5. The far future

5.1. Introduction

As already described in Chapter 2, among the possible embodiments of the emerging information society, an interesting and widely discussed potential instantiation is the Ambient Intelligence (AmI) paradigm. The information society is not seen as being characterised by an increased diffusion and use of present-day computers and telecommunication terminals, but as the emergence of an environment in which "people are surrounded by intelligent intuitive interfaces that are embedded in all kinds of objects and an environment that is capable of recognising and responding to the presence of different individuals in a seamless, unobtrusive and often invisible way" (Ducatel et al., 2001, p.8]. This concept provides a vision of the information society in which emphasis is put on greater user-friendliness, more efficient support of services, user-empowerment, and support for human interaction. Interaction is intended as taking place through "natural" interfaces in the context of an environment that meets the requirements of being unobtrusive (that is, it impinges on people's consciousness only when needed), personalisable, adaptive to different user needs, and anticipatory (that is, it tries to anticipate user needs).

The emergence and shaping of AmI is currently subject to debate. In order to produce a structured way for obtaining an impression on how an information society could emerge, a scenario planning exercise was conducted in Europe in 2000, leading to the publication of the report "Scenarios for Ambient Intelligence in 2010" (Ducatel et al., 2001). In this document, the vision of an information society is based on Ambient Intelligence as described in Chapter 1. The presented scenarios offer a view of a potential future, based on anticipated developments in technologies, society, the economy and networks which are necessary for implementing an environment in which the scenarios could actually become a reality. They are not technology forecasts, but descriptions of potential activities to be carried out in future ambient intelligent environments.

Despite the current limited knowledge on how AmI will materialise, it is commonly recognised that it is likely to bring about new opportunities for all citizens in the Information Society, including people with activity limitations and older people, but, at the same time, new challenges for access to computer-based products and services. As all technological innovations, Ambient Intelligence is not good or bad per se, but its impact on people will depend on how it is deployed and used, the time and scale of deployment and the care devoted to involve people in its development, taking care of their needs, requirements and preferences.

The purpose of the present chapter (Roe, 2006) is to analyse, through the ISTAG (IST Advisory Group) scenarios, the potential impact and consequences of AmI for people with activity limitations. This implies analysing how the scenarios would be affected in the case that their characters would not have all the abilities that are usually taken for granted for a "typical" user (for example if they cannot see, hear, move independently, and manipulate objects or they do not have the required cognitive abilities). An interesting issue to take into account is that, in the case of AmI, society is not facing the introduction of a new technology, but of an integrated set of technologies, which are supposed to have a profound impact on the way people live, work, learn, communicate, socialize and on the performance of everyday activities. Moreover, in most cases, they will only be perceived as additional functionalities made available in and by the surrounding environment. Therefore, an analysis of such an impact should in principle be multidisciplinary, involving psychological, economic, and sociological aspects. However, this is outside the scope of this chapter. The preliminary analysis presented is from a technological perspective and it is meant to show at the functional level what could be the potential impact of new technologies on the social inclusion of people with activity limitations.

The analysis is based on some assumptions, which must be made explicit to clarify the scope of the adopted approach. First of all the scenarios are considered as "true", that is, it is given for granted that the technology and services are available with the foreseen characteristics. For example, it is assumed that translation systems are available for all languages, including e.g. sign languages. Therefore, feasibility of technological developments is not considered in the analysis, and technology is considered at the functional level. The functions are considered as available irrespective of the real implementation. Second, the AmI environment is considered as available everywhere, not taking into account that economic factors could impede a real general deployment of the corresponding technology, Third, the AmI environment is considered as continuously available (without faults). An analysis of what could happen in case the last two assumptions do not hold has been presented in the SWAMI (Safeguards in a World of Ambient Intelligence) dark scenarios [Friedewald 2006], and applies also to people with reduced abilities (who have an higher risk of being in the less affluent part of the society and, therefore, forced not to use the most sophisticated technology).

Clearly, this approach shows some limitations. It can be considered as rather incomplete, because it does not consider all user groups, and reductionist, because the problem has been simplified up to the point to be manageable with the currently available resources. Moreover, only problems connected with *access to information* and *interpersonal communications* are considered. However, the results of this analysis are believed to provide a useful starting point for further investigation, offering some interesting conclusions, which constitute a building block for the construction of a more complete and holistic picture.

5.2. Development scenarios

Four scenarios were produced by ISTAG (Ducatel et al., 2001).

5.2.1. Scenario 1: 'Maria' – Road Warrior

After a tiring long haul flight Maria passes through the arrivals hall of an airport in a Far Eastern country. She is travelling light, hand baggage only. When she comes to this particular country she knows that she can travel much lighter than less than a decade ago, when she had to carry a collection of different so-called personal computing devices (laptop PC, mobile phone, electronic organisers and sometimes beamers and printers). Her computing system for this trip is reduced to one highly personalised communications device, her 'P–Com' that she wears on her wrist. A particular feature of this trip is that the country that Maria is visiting has since the previous year embarked on an ambitious Ambient Intelligence infrastructure programme. Thus her visa for the trip was self-arranged and she is able to stroll through immigration without stopping because her P-Com is dealing with the ID checks as she walks.

A rented car has been reserved for her and is waiting in an earmarked bay. The car opens as she approaches. It starts at the press of a button: she doesn't need a key. She still has to drive the car but she is supported in her journey downtown to the conference centre-hotel by the traffic guidance system that had been launched by the city government as part of the 'AmI-Nation' initiative two years earlier. Downtown traffic has been a legendary nightmare in this city for many years, and draconian steps were taken to limit access to the city centre. But Maria has priority access rights into the central cordon because she has a reservation in the car park of the hotel. Central access however comes at a premium price, in Maria's case it is embedded in a deal negotiated between her personal agent and the transaction agents of the car-rental and hotel chains. Her firm operates centralised billing for these expenses and uses its purchasing power to gain access at attractive rates. Such preferential treatment for affluent foreigners was highly contentious at the time of the introduction of the route pricing system and the government was forced to hypothecate funds from the tolling system to the public transport infrastructure in return. In the car Maria's teenage daughter comes through on the audio system. Amanda has detected from 'En Casa' system at home that her mother is in a place that supports direct voice contact. However, even with all the route guidance support Maria wants to concentrate on her driving and says that she will call back from the hotel.

Maria is directed to a parking slot in the underground garage of the newly constructed building of the *Smar-tel Chain*. She is met in the garage by the porter – the first contact with a real human in our story so far! He helps her with her luggage to her room. Her room adopts her 'personality' as she enters. The room temperature, default lighting and a range of video and music choices are displayed on the video wall. She needs to make some changes to her presentation – a sales pitch that will be used as the basis for a negotiation later in the day. Using voice commands she adjusts the light levels and commands a bath. Then she calls up her daughter on the video wall, while talking she uses a traditional remote control system to browse through a set of webcast local news bulletins from back home that her daughter tells her about. They watch them together.

Later on she '*localises*' her presentation with the help of an agent that is specialised in advising on local preferences (colour schemes, the use of language). She stores the presentation on the secure server at headquarters back in Europe. In the hotel's seminar room where the sales pitch is take place, she will be able to call down an encrypted version of the presentation and give it a post presentation decrypt life of 1.5 minutes. She goes downstairs to make her presentation… this for her is a high stress event. Not only is she performing alone for the first time, the clients concerned are well known to be tough players. Still, she doesn't actually have to close the deal this time. As she enters the meeting she raises communications access thresholds to block out anything but red-level 'emergency' messages. The meeting is rough, but she feels it was a success. Coming out of the meeting she lowers the communication barriers again and picks up a number of amber level communications including one from her cardio-monitor warning her to take some rest now. The day has been long and stressing. She needs to chill out with a little meditation and medication. For Maria the meditation is a concert on the video wall and the medication….a large gin and tonic from her room's minibar.

5.2.2. Scenario 2: 'Dimitrios' and the Digital Me' (D-Me)

It is four o'clock in the afternoon. Dimitrios, a 32 year-old employee of a major food-multinational, is taking a coffee at his office's cafeteria, together with his boss and some colleagues. He doesn't want to be excessively bothered during this pause. Nevertheless, all the time he is receiving and dealing with incoming calls and mails.

He is proud of 'being in communication with mankind': as are many of his friends and some colleagues. Dimitrios is wearing, embedded in his clothes (or in his own body), a voice activated 'gateway' or digital avatar of himself, familiarly known as 'D-Me' or 'Digital Me'. A D-Me is both a learning device, learning about Dimitrios from his interactions with his environment, and an acting device offering communication, processing and decision-making functionality. Dimitrios has partly 'programmed' it himself, at a very initial stage. At the time, he thought he would 'upgrade' this initial data periodically. But he didn't. He feels quite confident with his D-Me and relies upon its 'intelligent' reactions.

At 4:10 p.m., following many other calls of secondary importance – answered formally but smoothly in corresponding languages by Dimitrios' D-Me with a nice reproduction of Dimitrios' voice and typical accent, a call from his wife is further analysed by his D-Me. In a first attempt, Dimitrios' 'avatar-like' voice runs a brief conversation with his wife, with the intention of negotiating a delay while explaining his current environment. Simultaneously, Dimitrios' D-Me has caught a message from an older person's D-Me, located in the nearby metro station. This senior has left his home without his medicine and would feel at ease knowing where and how to access similar drugs in an easy way. He has addressed his query in natural speech to his D-Me. Dimitrios happens to suffer from similar heart problems and uses the same drugs. Dimitrios' D-Me processes the available data as to offer information to the senior. It 'decides' neither to reveal Dimitrios' identity (privacy level), nor to offer Dimitrios' direct help (lack of availability), but to list the closest drug shops, the alternative drugs, offer a potential contact with the self-help group. This information is shared with the senior's D-Me, not with the senior himself as to avoid useless information overload.

Meanwhile, his wife's call is now interpreted by his D-Me as sufficiently pressing to mobilise Dimitrios. It 'rings' him using a pre-arranged call tone. Dimitrios takes up the call with one of the available Displayphones of the cafeteria. Since the growing penetration of D-Me, few people still bother to run around with mobile terminals: these functions are sufficiently available in most public and private spaces and your D-Me can always point at the closest…functioning one! The 'emergency' is about their child's homework. While doing his homework their 9 year-old son is meant to offer some insights on everyday life in Egypt. In a brief 3-way telephone conference, Dimitrios offers to pass over the query to the D-Me to search for an available direct contact with a child in Egypt. Ten minutes later, his son is videoconferencing at home with a girl of his own age, and recording this real-time translated conversation as part of his homework. All communicating facilities have been managed by Dimitrios' D-Me, even while it is still registering new data and managing other queries. The Egyptian correspondent is the daughter of a local businessman, well off and quite keen on technologies. Some luck (and income…) had to participate in what might become a longer lasting new relation.

5.2.3. Scenario 3 - Carmen: traffic, sustainability & commerce

It is a normal weekday morning. Carmen wakes and plans her travel for the day. She wants to leave for work in half an hour and asks AmI, by means of a voice command, to find a vehicle to share with somebody on her route to work. AmI starts searching the trip database and, after checking the willingness of the driver, finds someone that will pass by in 40 minutes. The invehicle biosensor has recognised that this driver is a non-smoker – one of Carmen's requirements for trip sharing. From that moment on, Carmen and her driver are in permanent contact if wanted (e.g. to allow the driver to alert Carmen if he/she will be late). Both wear their Personal Area Networks (PAN) allowing seamless and intuitive contacts.

While taking her breakfast coffee Carmen lists her shopping since she will have guests for dinner tonight. She would like also to cook a cake and the e-fridge flashes the recipe. It highlights the ingredients that are missing: milk and eggs. She completes the shopping on the e-fridge screen and asks for it to be delivered to the closest distribution point in her neighbourhood. This can be a shop, the postal office or a franchised nodal point for the neighbourhood where Carmen lives. All goods are smart tagged, so that Carmen can check the progress of her virtual shopping expedition, from any enabled device at home, the office or from a kiosk in the street. She can be informed during the day on her shopping, agree with what has been found, ask for alternatives, and find out where they are and when they will be delivered.

Forty minutes later Carmen goes downstairs onto the street, as her driver arrives. When Carmen gets into the car, the VAN system (Vehicle Area Network) registers her and by doing that she sanctions the payment systems to start counting. A micro-payment system will automatically transfer the amount into the e-purse of the driver when she gets out of the car.

In the car, the dynamic route guidance system warns the driver of long traffic jams up ahead due to an accident. The system dynamically calculates alternatives together with trip times. One suggestion is to leave the car at a nearby 'park and ride' metro stop. Carmen and her driver park the car and continue the journey by metro. On leaving the car, Carmen's payment is deducted according to duration and distance.

Out of the metro station and whilst walking a few minutes to her job, Carmen is alerted by her PAN that a Chardonnay wine that she has previously identified as a preferred choice is on promotion. She adds it to her shopping order and also sets up her homeward journey with her wearable. Carmen arrives at her job on time.

On the way home the shared car system senses a bike on a dedicated lane approaching an intersection on their route. The driver is alerted and the system anyway gives preference to bikes, so a potential accident is avoided. A persistent high-pressure belt above the city for the last ten days has given fine weather but rising atmospheric pollutants. It is rush hour and the traffic density has caused pollution levels to rise above a control threshold. The city-wide engine control systems automatically lower the maximum speeds (for all motorised vehicles) and when the car enters a specific urban ring toll will be deducted via the Automatic Debiting System (ADS).

Carmen arrives at the local distribution node (actually her neighbourhood corner shop) where she picks up her goods. The shop has already closed but the goods await Carmen in a smart delivery box. By getting them out, the system registers payment, and deletes the items from her shopping list. The list is complete. At home, her smart fridge screen will be blank.

Coming home, AmI welcomes Carmen and suggests to telework the next day: a big demonstration is announced downtown.

5.2.4. Scenario 4 – Annette and Solomon in the Ambient for Social Learning

It is the plenary meeting of an environmental studies group in a local 'Ambient for Social Learning'. The group ranges from 10 to 75 years old. They share a common desire to understand the environment and environmental management. It is led by a mentor whose role it is to guide and facilitate the group's operation, but who is not necessarily very knowledgeable about environmental management. The plenary takes place in a room looking much like a hotel foyer with comfortable furniture pleasantly arranged. The meeting is open from 7.00-23.00 hours. Most participants are there for 4-6 hours. A large group arrives around 9.30 a.m. Some are scheduled to work together in real time and space and thus were requested to be present together (the ambient accesses their agendas to do the scheduling).

A member is arriving: as she enters the room and finds herself a place to work, she hears a familiar voice asking "Hello Annette, I got the assignment you did last night from home: are you satisfied with the results?" Annette answers that she was happy with her strategy for managing forests provided that she had got the climatic model right: she was less sure of this. Annette is an active and advanced student so the ambient says it might be useful if Annette spends some time today trying to pin down the problem with the model using enhanced interactive simulation and projection facilities. It then asks if Annette would give a brief presentation to the group. The ambient goes briefly through its understanding of Annette's availability and preferences for the day's work. Finally, Annette agrees on her work programme for the day.

One particularly long conversation takes place with Solomon who has just moved to the area and joined the group. The ambient establishes Solomon's identity; asks Solomon for the name of an ambient that 'knows' Solomon; gets permission from Solomon to acquire information about Solomon's background and experience in Environmental Studies. The ambient then suggests Solomon to join the meeting and to introduce himself to the group.

In these private conversations the mental states of the group are synchronised with the ambient, individual and collective work plans are agreed and in most cases checked with the mentor through the ambient. In some cases the assistance of the mentor is requested. A scheduled plenary meeting begins with those who are present. Solomon introduces himself. Annette gives a 3-D presentation of her assignment. A group member asks questions about one of Annette's decisions and alternative visualisations are projected. During the presentation the mentor is feeding observations and questions to the ambient, together with William, an expert who was asked to join the meeting. William, although several thousand miles away, joins to make a comment and answers some questions. The session ends with a discussion of how Annette's work contributes to that of the others and the proposal of schedules for the remainder of the day. The ambient suggests a schedule involving both shared and individual sessions.

During the day individuals and sub-groups locate in appropriate spaces in the ambient to pursue appropriate learning experiences at a pace that suits them. The ambient negotiates its degree of participation in these experiences with the aid of the mentor. During the day the mentor and ambient converse frequently, establishing where the mentor might most usefully spend his time, and in some cases altering the schedule. The ambient and the mentor will spend some time negotiating shared experiences with other ambients – for example mounting a single musical concert with players from two or more distant sites. They will also deal with requests for references / profiles of individuals. Time spent in the ambient ends by negotiating a homework assignment with each individual, but only after they have been informed about what the ambient expects to happen for the rest of the day and making appointments for next day or next time.

5.3. Methodological considerations

In the ISTAG scenarios, the deployment of innovative technology is reported, and possible activities to be carried out in the resulting intelligent environment are described. A fundamental problem is to consider how people are able to perform the foreseen activities, according to their abilities in the AmI environment, defined as the combination of the physical environment, the network, its data bases, etc. Living in the environment includes the use of general purpose services and local interactions. This is important for all potential users, but crucial for people who have limitations in some of the required abilities. For example, in the scenarios it is taken for granted that people can see screens, hear speech and sounds, and speak.

Several approaches can be chosen to draw conclusions about the level of inclusion of people with different activity limitations. The first is to construct new specific scenarios for these target groups, trying to describe situations which identify new opportunities offered by the integrated use of AmI technology, and emphasise potential problems. A second approach is to modify the ISTAG scenarios in order to adapt them to the needs of people with different activity limitations. Both approaches have their advantages and could lead to interesting results, in terms of identifying examples of inclusion or segregation of people in the emerging information society.

In the present analysis a mainstreaming approach was chosen, whereby characters with different activity limitations are introduced in the ISTAG scenarios, identifying how they can carry out necessary activities in such an environment. This is made possible by the fact that one of the interesting new characteristics of the ISTAG scenario exercise is that the user appears at the centre of interest, adopting a holistic, citizen-centred view (IST Advisory Group, 2003). This is also shown by the approach used in investigating future developments. Instead of starting from new technology and trying to figure out how this can be used to implement new services and applications, the analysis starts from application scenarios that exemplify at the activity level the use of different aspects of the intelligent environment.

What is considered important is that, in the formation of the scenarios, people - and not technology - are at the forefront of the information society. The scenarios do not make explicit reference to people with activity limitations; however, as they are mainly based on activities in defined contexts, they lend themselves to an easy analysis of the possibility of access to these activities by persons with different characteristics.

The approach is also in line with the one at the basis of the preparation of the new WHO “International Classification of Functioning, Disability and Health (ICF)”[76], where a balance is sought between a purely medical and a purely social approach to the identifications of problems and opportunities for people in their social inclusion.

When dealing with the problems of people who experience some degree of activity limitation or participation restrictions, “ICF uses the term *disability* to denote a multidimensional phenomenon resulting from the interaction between people and their physical and social environment”. This is very important, because it allows grouping and analysis of limitations that are not only due to impairments. For example, people are not able to see because they are blind, or have fixation problems due to spastic cerebral palsy, or are in a place with insufficient illumination, or are driving and therefore cannot use their eyes for interacting with an information system.

People may have impairments, activity limitations or participation restrictions that characterise their ability (capacity) to execute a task or an action (activity), but their performance is influenced by the

[76] http://www3.who.int/icf/icftemplate.cfm

current environment. The latter can increase the performance level over the capacity level (and therefore is considered a facilitator) or can reduce the performance below the capacity level (thus being considered as a barrier).

The purpose of the work presented in this chapter is to analyse how people perform in the situations foreseen in the AmI environment to characterise it as a *facilitator* in the required activities, or as a *barrier*, hopefully also pointing out possible ways to overcome such a barrier. For this purpose, ISTAG scenarios are divided into activities, and some user groups having activity limitations are "virtually observed" while performing the corresponding necessary tasks.

In order to structure the work, tables have been constructed with several rows (activities) and four columns: (1) an ISTAG scenario fragment describing an activity or a set of related activities, (2) problems (barriers), and (3) possible solutions and (4) AmI opportunities (increase in performance). The tables are reported in Appendix 1. The comments in the columns are clustered and used to draw conclusions at a general level. Obviously, starting from the comments in columns 3 and 4, ISTAG scenarios, modified to take into account problems of people with activity limitations, can be produced.

Due to the enormous variability of the possible individual impairments, activity limitations or participation restrictions and the number of necessary activities to be carried out for a satisfactory inclusion in the information society, it is impossible to analyse all possible combinations corresponding to the ICF classification. Therefore, a set of examples were worked out, using some typical profiles concerning activity limitations in connection with the activities foreseen in the ISTAG scenarios.

Five user groups were considered. The first two groups address people with sensorial limitations (also caused by contextual factors), and precisely *people who cannot see at all* and *people who cannot hear at all*. The third group addresses *people with mild or moderate limitations in memory, language, orientation and problem solving (cognitive limitations)*, mainly made up of older people. In the scenarios reference is mainly made to people who have mild or moderate memory, language, orientation and problem solving problems that normally do not impede their independent living, suitably supported. Then, *people with manipulation problems* (that is control of fine manipulation operations necessary in the use of a keyboard or a mouse), *fixation problems and/or difficulties in expressing themselves using voice* (e.g. caused by spastic cerebral palsy) are considered. In the discussion, only problems related to access to information and interpersonal communication are considered. Therefore, it is assumed that people considered in the analysis are able to move around without using a wheelchair. Finally, *people moving in a wheelchair* are considered, dealing only with their problems of access to information and interpersonal communication.

It has been previously said that, for the purposes of the performed analysis, the ISTAG scenarios have been used in their original form. This must not be considered literally, because some changes have been introduced to make them credible, particularly in the case of cognitive limitations. For example, it is very unlikely that an older person acts as a "road warrior". Therefore, Maria in the specific scenario is a tourist going to a foreign country and living in a hotel. She is not supposed to give a presentation. Correspondingly, Carmen, in the revised scenario, does not go to the city to work, but to visit a friend.

5.4. Impact on users with activity limitations

5.4.1. New technology, systems and services

Before delving in the general analysis of the scenarios, it is useful to briefly comment on some of the technologies that are anticipated to emerge, and their integration in systems and services from the perspective of the users and in relation to Assistive Technology. The aim of this discussion is to provide hints on the possible smooth transition from the present situation and AmI-like environments. As a matter of fact, as discussed in the previous chapter, some emerging technologies can offer interesting possibilities for improvements in Assistive Technology in the short and medium terms, aiming in the long term at a confluence of concepts developed in the Assistive Technology environment in the development of mainstream technology.

In looking back at the efforts to produce interfaces for computers and terminals adapted for people with disabilities, the technology necessary in order to support an intelligent environment seems to have much to offer.

One of the main prerequisites of the intelligent environment is that interactions must be multimodal and alternative input-output systems must be available. In principle, the different modalities can be used concurrently so as to increase the quantity of information made available or, alternatively, to present the same information in different contexts, or, redundantly, to address different interaction channels, both to reinforce a particular piece of information or to cater for the different abilities of users. Obviously any redundancy in the presentation of information can be important for people who do not have available one of more sensorial channel.

Moreover, research on multimodality can concur to the development of technology of interest for people with sensorial limitations. Voice synthesis and recognition can be considered as an example. For recognition, the goal set in AmI is the recognition of connected speech in noisy environments. This can obviously be very important in producing efficient inputs for people who cannot use keyboards or object manipulation techniques due to activity or contextual limitations. Correspondingly, voice synthesis is anticipated not only to achieve better quality, but also to incorporate personal characteristics (in the Dimitrios scenario, his network agent is able to speak with his voice). From the perspective of people who have problems in speaking, this should make possible the implementation of speech prostheses using a voice chosen by the user.

Another design target is the development of *automatic translation* up to the point of being used in real-time conversation between people speaking different languages. Even if, at least in an initial phase, this will be probably possible only in limited communication contexts, the related technology can eventually be extended to the translation between non-conventional languages (for example, speech to Bliss symbols and vice versa).

Input prediction, which was initially developed in the disability area and is now widely used for writing SMSs in GSM telephones, will be extended, with obvious advantages for the group of people for whom it was initially developed.

Special *vibrating materials* for alerting people are considered important, and will increase the efficiency of many alarm systems that have previously been used by people who cannot receive messages using auditory signals. These developments are also related to the study of materials capable of sensing touch or producing tactile presentations of information. These technologies, which were initially developed for virtual reality systems in order to sense force information or to emulate interaction with objects, are progressively acquiring importance in many different environments, including not only in touch screens, but also in systems capable of transducing information into a tactile presentation. Moreover, *tactile* presentation of information should also be three-dimensional: that is, materials capable of reproducing three-dimensional forms in real time are being sought. This might make the present transitory Braille displays obsolete, because any output tactile screen could be capable of reproducing Braille. It could also be an answer to the need of people who cannot see to access graphical and pictorial information.

GPS and other localisation systems are likely to become standard in many pieces of equipment and services. This will solve the problem of tracing people who risk being lost in open spaces, and will help in navigation (e.g., for people who cannot see). However, for this second application, GPS precision should be improved. This, for example, can be obtained in closed spaces where in any case the GPS system cannot be used. GPS localisation should be integrated by the deployment of networks of sensors (Estrin, 2002; Lorincz, 2004), e.g. based on ultrasound beacons, floor sensors to determine the positions and movements of individuals, weight sensors, worn badges that emit IR pulses, and smart tags to identify objects.

Smart tags are another important technology necessary for the development of an intelligent environment. They can signal the presence of objects in the environment, and can provide detailed information about the objects to which they are attached. In the Carmen scenario, they are used to give Carmen information about what is contained in the refrigerator, and to produce the list of goods to be bought in the supermarket, which is directly transmitted by the refrigerator itself. This technology could have a number of very important applications for people with activity limitations. A person who cannot see, equipped with a simple radio transducer could be directly informed about the items on the shelves of a supermarket. For each object, s/he could have information about weight, expiring date, composition, and so on. At home, the same person could be able to locate all kinds of small objects, for example a box of pills or spectacles, and when necessary, have information about the medicament and the dosage. The pill box could also be authorised to make the person aware of its presence, if s/he tends to forget about medication. The tags on objects in the house could be used as a means to help older people or people with memory problems by making available, when necessary, information concerning their presence and use.

Gesture recognition (Geer, 2004) is an additional important component of a new generation of systems for people with activity limitations. It can be used both to implement virtual keyboards on any surface and virtual pointing devices, and to produce interfaces for the manipulation of objects on the screen, as it is now possible with computer games. The traditional switches used by people with manipulation limitations to activate controls or to interact with computers could become virtual switches. The mouse could become a virtual mouse, whose movements can be controlled through movements in space of any predefined form, using a TV camera and appropriate image processing algorithms or mio-electric signals (Wheeler, 2003). Other, more sophisticated interfaces can also be conceived, such as interfaces based on the recognition of lip movements and their "transduction" into text. Sign-language interfaces could be implemented with the use of gesture recognition. Correspondingly, animation technology developed for game or film production can be used to produce good-quality avatars that are able to sign or to move lips for lip reading.

Visualisation technologies are considered of paramount importance (Abowd, 2002). The idea is that screens should be available everywhere. Any surface in the environment could be easily transformed into a screen. New materials are under study to produce screens that are lightweight and foldable, thus making possible visual presentation systems that follow the user while moving (nomadicity and availability). Alternatively, the presentation screen could be virtual, using projection systems, and the presentation of 3-D information should be possible.

The importance of concepts and technologies related to *intelligent agents* also needs to be emphasised. People in the information society will be represented by different digital agents which will sometimes be disembodied representations of the individuals; at other times, they will be visual and audio representations (avatars). At a lower level, these should be able to explore the network in order to extract information of interest. At a higher level, they will represent users in negotiations with people and other agents. For example, in the Maria scenario, her agent negotiates to have a rented car at a reduced price, to obtain a discounted permit to enter the city centre where cars are allowed only on the basis of payment, and to book a parking place in the hotel. In Dimitrios' scenario, D-Me, an intelligent agent which represents the owner (not visually, but speaking with his voice), is allowed to negotiate with a person asking help for a medical problem (the agent decides to follow an impersonal strategy, without revealing the identity of the person represented) and with Dimitrios' wife. Obviously, in the latter case, the agent rightly loses and allows direct communication with Dimitrios on the basis of the "emotion" it can feel in the woman's voice (based on emotion understanding approaches). This technology - with obvious problems of privacy and control for the user - is very promising in different situations. People who cannot see can be supported by agents able to access visual information for them and to "transduce" information produced by them into visual form for sighted people. The same is true for people who cannot hear regarding accessing and producing auditory information. An intelligent agent could also take care of helping people with cognitive difficulties due to impairment or age in acquiring information from the environment, and could anticipate their needs for communication and environmental control.

Lastly, a common requirement of new technology is *miniaturisation*. Many technologies are conceived as hand-held or wearable, taking also advantage of the fact that intelligence can be embedded in the environment in order to support the individual personal system. This means being light-weight, which can be important for some people and in some environments, but also availability. It is taken for granted that people can have with them everything necessary for performing even complex tasks. An example is Maria, whose only technological item (sufficient for carrying out navigation, environmental control and making a complex business presentation) is a personal communicator that she wears as a wrist bracelet.

From the above, some conclusions can be drawn about general characteristics of systems and services in the intelligent environment. Systems and services are nomadic, that is, they follow people. The basic system for accessing communication or information is personal (a personal communicator). It is simply a portable link with the infrastructure where the intelligence resides. It is small, wearable, and also implantable, as well as personalisable as much as is it necessary. Consequently, digital services are ubiquitous in the environment, wherever and whenever people need them, and there is no need to look for terminals, as terminals are always with people. Additionally, the infrastructure can help people to navigate and find objects in the environment (for example, medications, etc).

5.4.2. *The environment as a general facilitator*

So far, as already mentioned, the inclusion of people with activity limitations has been based on some complementary approaches: adaptation of systems addressing the needs of individual user groups (e.g., by adapting their human computer interfaces), adaptation of services of general use (e.g., alarm services), and creation of special services (e.g., relay services).

Some interesting conclusions can be drawn from the scenarios, with reference to services available in the environment. In order to simplify the discussion, this section addresses issues related to the environment's foreseen functionality, envisaging how it can potentially impact on inclusion, while next section deals with issues related to interaction.

5.4.2.1. Environmental control systems

First of all, environmental control systems, introduced for the independent living of persons with motor disabilities, become an integral part of the living environment. Probably, the environment will not be equipped by default with robot-type systems useful for taking care of certain needs of people with motor disabilities, such as feeding them or moving them around. However, it will be able to integrate this additional technology if it is has been designed in such a way as to be extendable to incorporate additional facilities (either for general purposes, e.g., robotic systems, or for specialised support, e.g., assistive technologies).

5.4.2.2. Relay services

Another type of service (*relay services*) of interest for people who cannot hear/and or speak is in principle available by default in the Ambient Intelligence environment, where voice recognition and synthesis, automatic translation, gesture recognition (sign language and lip reading) and animation (synthetic sign language and lips movements) are available. Relay services may really be a default facility if the environment is developed following with a design for all approach. Alternatively, a personal communicator, such as the one described in the Dimitrios' scenario, can be used as a personal relay service.

5.4.2.3. Agent-based information, communication and negotiation services

The real winning factor is the intelligence in the environment (intelligent agents). To plan her travel, Maria relies on an environment populated by agents (the intelligence in the environment), which can look for relevant information and negotiate on her behalf to get what she needs at the best possible prize. Another agent helps her in localising her presentation according to local preferences (colour schemes, the use of language). This intelligent support, of interest to everybody, can be crucial for people who have some hearing or speech problems that can reduce interpersonal communication or sight and manipulation problems that can reduce efficiency in accessing complex information services. The possibility of delegating to an agent the transactions needed for organising a trip abroad can also be crucial for an older person with cognitive limitations. The same holds for the Carmen scenario, where agent-based support systems help her in organising the travel to the city using a car pooling system and in her e-shopping activities. This can be useful not only to help Carmen when she is really unable to perform required tasks, but also to reduce stress. In the negotiation for travel arrangements to the city, the agent knows the needs of Carmen (for example she is travelling in a wheelchair) and can fine-tune the choice of a suitable car and driver. In e-shopping the agent can look for the information which is useful for the user and present it in the suitable form. If Carmen can see, the goods on the supermarket shelf can be shown on a screen. If Carmen cannot see, or has fixation problems, the agent can read information on the intelligent tags attached to each item. If Carmen has cognitive limitations, it may be that she needs guidance through the required actions. The level of support by AmI can be matched to the severity of Carmen's problems. In cases of mild cognitive problems, AmI can remind and provide suggestions, just like a friend in the house (for example, Carmen is reminded that she will have guests for dinner and is suggested a selection of menus extracted from her known preferences). In case of more severe problems, AmI can completely control the situation: preparing a balanced diet for Carmen based on past habits, checking the availability of food, ordering it, caring for its delivery at home, and suggesting all the steps necessary for its preparation. Obviously, it can also supervise the preparation of food from a security perspective. This can be done autonomously or in cooperation with a relative or carer. The level of control by Carmen can be set at any possible or desired level.

The Dimitrios scenario is completely about an agent (avatar), called D-Me, that takes care as far as possible of his communication with the outside world, and can manages services (e.g., choosing the best telecommunication means for Dimitrios' child). Before being overridden by Dimitrios' wife, who is able to pass through the D-Me barrier, D-Me is able to deal with routine calls, facilitating him if he has sensorial or speech problems that reduce his communication capabilities and avoiding the use of complex interfaces. If Dimitrios has cognitive problems, being continuously in contact can be very useful. His D-Me can overcome some of his problems with memory and problem solving. Automatic learning can improve in the long term the agent's adaptation to Dimitrios' behaviour, and assist with the short term fluctuations of his capabilities. Moreover, in social contacts mediated by telecommunication, where Dimitrios is directly interacting with other people, D-Me can try to overcome Dimitrios' cognitive problems, if present, by dealing with complex tasks, interactions and problem solving functions. It can also hide other activity limitations (e.g., sensorial) of Dimitrios, who is apparently performing in a "normal" way. Only when Dimitrios is communicating with his wife or in other situations that need his personal intervention his limitations are exposed.

5.4.2.4. Navigation services

When arriving at her destination, Maria is connected with the environment that guides her through the customs and to the taxi, and then in her navigation through the city. Navigation systems and services are an integral part of the intelligent environment, and can be useful in many circumstances. They are present or can be used in all scenarios for different purposes. If Maria is not able to see, the P-Com in communication with AmI guides her through the airport (e.g., by voice, or using haptic cues). This requires the knowledge of her position in the airport (granted by AmI) and the possibility of controlling the presence of unpredictable obstacles (people, baggage, etc.), obtainable through the use of features of the AmI itself (e.g., a control system able to monitor tagged objects and communicate with the P-com of passengers). If Maria has cognitive limitations, the navigation system may tune the level of support to the known abilities or to the perceived present difficulties (for example, Maria may be confused by the crowd in the airport) and identify not tagged objects using real time pattern recognition systems. Dimitrios and Annette, if unable to see, need navigation help in the cafeteria and in the room where learning activities are taking place. Even if the two environments are reconfigurable, it is reasonable to think that AmI knows the position of all potential obstacles (e.g., by reading RFID on objects or through direct optical inspection by pattern recognition), and is able to guide them. Carmen, while moving towards the meeting point with the car driver, may need to be reminded the route to follow, as well as help for orientation.

Moreover, the car is part of a very complex navigation and traffic control system. Carmen does not interact directly with the system, but the system knows her characteristics and is able to suggest a reasonable alternative when she needs to leave the car and use an alternative transportation system. For example, the UAN (Underground Network Area) registers Carmen as a client who cannot see and suggests routes and paths that are not too busy at that point, so she can manage to be at work on time. Alternatively, The UAN registers Carmen as an older client. It connects with the control centre to verify whether Carmen may be allowed to travel alone with the metro or she must be assisted. If she can travel alone, the P-com takes care of guiding her through the space and advising her about the tasks necessary for arriving to her friend's house. The level of support can be easily tuned to Carmen's capabilities (probably changing in time). If Carmen is moving around on a wheelchair, AmI can suggest an accessible route to destination. When Carmen must meet with the driver, if she cannot see, it may be that unexpected obstacles are on her way. AmI can advice her, but it is more likely that she relies on her virtual[77] or real dog. If she has cognitive problems, AmI can guide her to the meeting point.

5.4.2.5. Learning activities

The space where the Annette and Solomon scenario is located, as well as the organisation of the learning activities, are particularly interesting from the perspective of people with activity limitations. A first very important feature of the environment is its possibility of being tailored physically (organization of space and availability of multimedia support) and conceptually (type of learning material, speed of presentation) to individual users. Moreover, there is a mix of social exchanges (with other learners, the mentor and external experts) that can be of invaluable help for this user group. The mentor himself is not an expert in the topics to be learned, but a mediator between different interests and needs. Not only the efficiency of learning is addressed, but also the emotions of individuals and groups. A continuous support is granted by AmI that is able to adapt to the users and to their emotional states.

From a technical perspective, the cooperation of the personal communicator with AmI can allow the structuring of the environment to allow easy physical navigation by all the potential users. For example, the space can be arranged to allow a person on a wheelchair to move around without any problem. Moreover, the possibility of creating virtual spaces allows the optimisation of each working place for the individual user or a group of users with different capabilities. Different user groups can interact with the system and people can use the approaches already described in the previous example to interact with other people and access information.

5.4.2.6. Alarm and support/control services

The entire AmI is a pervasive and very sophisticated alarm and support/control system. This may be very important for people with cognitive problems. AmI can continuously control Maria's behaviour in the various environments according to her known habits and intervene if necessary, for example reminding her of tasks and helping her perform them. When necessary, AmI can also contact the family or a carer for advice and help. If Maria cannot see AmI is able, if necessary, to describe its layout and functionalities, as well as the functionalities of its devices (e.g., the remote control of the

[77] A virtual dog is set of sensors (e.g., a worn T.V. camera, or some type of ultrasound or laser) able to spot obstacles.

hotel room). Moreover, since Maria cannot do two acoustic activities simultaneously, AmI is able to organize sequentially the flow of information and the performance of the necessary tasks, allocating the necessary time. In the Dimitrios scenario, D-Me can be part of a control system, in continuous contact with relatives or helpers. In the Carmen scenario, the P-com can transmit the news that Carmen is leaving home to a control centre or to a relative. A continuous connection can then be established, and Carmen can be tracked during her trip. Moreover, the micro-payment system frees Carmen from financial transactions. On the way home, the shared car system senses a bike on a dedicated lane approaching an intersection on their route. The driver is alerted and the system anyway gives preference to bikes, so a potential accident is avoided. The same service could be very useful for a person who is on a wheelchair and for a person who cannot see. This can also be an invaluable help for Carmen when going around alone. If the system becomes aware of Carmen's problems, for example evident confusion in finding her way and problems in coping with the environment, it can connect with a relative or a control centre. The connection can be granted by Carmen's P-com without infringement of her privacy. A complex situation also arises when Carmen must leave the car to use a public transportation service. However, the navigation system takes care of that, and a support/control system can intervene if she has particular problems or has a reduction in cognitive capacities.

5.4.2.7. Broadband communication facilities

The additional opportunities offered by AmI are related to the availability of *broadband communication facilities*. Maria' scenario offers a presentation of advanced telecommunication facilities, in the car, in the hotel room and in the presentation room. When Maria is driving, she is tracked by the navigation system and people know (if she wants) that she can be contacted. If she is contacted in a difficult situation and she does not want to answer, a D-Me type agent can deal with the calls when they are not considered important or advice that she should call back as soon as possible. In the hotel room there is an audio/video system, the video scenes of which are described if she cannot see, and automatically captioned, if she cannot hear. The audio/video system can be used also for communication with her daughter, with whom she can not only communicate, but also go through the news as they watch them at the same time from different environments. Obviously, if she cannot see, she listens to the news, while if she cannot hear she can read the news, which is automatically captioned. Conversation with her daughter takes place through AmI and the P-Com (relay service).

5.4.2.8. Audio/video interpersonal communication services

The fact that Maria and her daughter are able to converse on an audio/video system and cooperatively access information, is very important from two different perspectives. The first is that it introduces a remote socialisation component, which can be crucial to reduce stress, and through which Maria can be supported. Even if support by technology can be of invaluable value in some circumstances, support by other people can be more efficient and acceptable in some situations and activities. It can introduce a personal dimension, which increases acceptability and efficiency in the intervention. AmI, with its emphasis on cooperative activities, whereby people can remotely carry out common activities with audio and visual contact, can increase the feasibility of the approach. When people are not able to perform some actions, they can ask a relative, a friend or a support organisation. Maria, for example, if she cannot see, can show the hotel room to her daughter and get from her a personalised description that a computer system would had probably given in a functional form. If Maria knows that she has left an object somewhere in the room, her daughter can localise it. If Maria has cognitive problems, her daughter can instruct her when performing difficult tasks. In this case the advantage is reciprocal because the daughter can "control" that everything is all right without being too intrusive.

The same applies to the tasks related to the localisation of the presentation. If Maria does not trust the suggestion made by the localisation agent and she cannot see them, she can easily connect with a colleague in the office and ask for advice.

5.4.3. The individual interacting with the environment

After having examined the possible impact of services of general use on people who have some activity limitation, it is necessary to focus on the individual user and consider interaction with AmI in order to perform the tasks necessary to be integrated, at home, in closed spaces (e.g., the airport, the hotel, the cafeteria, and the learning environment), as well as in open spaces.

It is clear that the main key to open the doors of the information society is the personal communicator and the related set of agents, which are able to grant connection to the environment itself and to all its facilities for accessing information and interpersonal communication. Its characteristics are not precisely defined. It does not have a specifically defined interface, but it can in principle make available all the interaction technologies described in the previous sections in order to adapt the environment to the type of interaction suitable for the user and the context of use, for example, audio when eyes are necessary for other tasks (for driving in the Maria's scenario), or visual or tactile in noisy environments. It is very likely that the interface is not part of the communicator itself, but of the environment. The communicator is a disembodied functionality supported by the Ambient Intelligence with different interfaces. Maria wears it as a bracelet. In the case of Dimitrios, the communicator (D-Me) is embedded in his clothes but can be also implantable. It is adaptive, and learns from Dimitrios' interactions with the environment. It offers communication, processing and decision-making functions. Its functions may either be based on on-board intelligence or on distributed intelligence in the infrastructure. Both ways, it offers Dimitrios the necessary services. It deals with calls. When necessary, it becomes an avatar-like system and deals with most of his social communication, using his own voice. In the Carmen scenario, the communicator does not have a specific embodiment. It is a function, enabling contacts with other persons (for example, her host driver in the shared vehicle service) or with services (for example, the supermarket information system or the city payment system). There are some characteristics of the communicator important for all people: it is personal, lightweight, wearable, and continuously available.

Finally, it is interesting to observe that the personal communicator must not necessarily be a highly sophisticated piece of equipment, the performances of which are limited by size, weight, and power. The intelligence necessary to support the transduction of information necessary to address the different modalities and to support the user can be in the environment and in the network. The same is true for the complex interaction peripherals. In principle, the only limiting factor may be bandwidth.

Taking into account that all the characters in the scenarios have with them a personal communicator, it is interesting to discuss how they can interact with AmI in the information society if they have some activity limitations.

The simplest situation is at home or in other closed environments (e.g., the hotel room), because personal spaces are easier to personalise to the needs of different users, even if, as shown in the previous section, the distinction between close and open environments in AmI is blurred due to the ubiquitous deployment of functions. Carmen interacts with her fridge. If she is not able to see, she can receive audio messages. If she is not able to speak at all, she can use gesture recognition or text, and if she is not able to speak perfectly the voice recognition system can be trained to match the characteristics of the produced audio signal. Output can be given in any modality matching to the capabilities of the user. For example, when Carmen is connected to the shop, all the information stored in tags is translated in a properly encoded format for her to receive. Carmen may choose to see the goods of interest or hear or read (e.g., in Braille) brief descriptions of them, or to have a full presentation of a particular product or store shelf. Presentations may contain information about the product characteristics (size, colour, and weight), the packing, the price, potential offers or alternative selections and other information that will help her to make her choice. Carmen's P-workstation enables her to explore and manipulate 3D models and artefacts by means of tactile interaction.

The same approach can be used in communication with the car driver, who can have been made aware of Carmen's abilities, and thus use the most appropriate communication channel. Alternatively, the driver's and Carmen communicators can cooperate to transduce the information in a suitable modality.

The situation is more complex when a private but not personal space (e.g., the hotel room) is used. Even if the room is adapted to Maria's personality as she enters, i.e., the room temperature, default lighting and a range of video and music choices are displayed on the video wall according to her preferences, interaction with the room can pose some problems. Obviously, interaction with the room for adjusting features to the varying needs of its inhabitant can be solved using the same methodology used at home for interacting with the fridge, but some difficulties remain. The first is that Maria may have problems with the room itself, if she cannot see or has some cognitive problems. In this case, a description of the room and its facilities may be provided by AmI itself. If cognitive problems are present, the number and complexity of facilities to be made available can be chosen according to Maria's profile. If necessary, the room can make all choices automatically. Otherwise, suggestions can be offered by relatives or carers.

Similar problems can be experienced with the remote control of the room, if Maria cannot see, or she cannot manipulate it or understand its functioning. A first efficient solution to the problem is for Maria to use her P-Com, which obviously can be programmed to mimic any remote control. Support by personal equipment well known by the user is very important, because the same approach can be used in different environments, without the need of learning new interaction styles and patterns of presentation of information each time. However, this is due not only to the use of adapted equipment, but also to its integration with AmI. Alternatively, AmI can describe to Maria the layout and the functionalities of the remote control available in the room, and its functions can be simplified according to her characteristics and preferences

In the Maria's scenario, she gives a presentation. If she cannot see, she needs to know who is in the room, when she can start her presentation, and how to control the pace of the presentation. The P-Coms communicate and exchange the information on who is attending the meeting. She gets a multi-modal confirmation (voice through earphone plus vibrator) that the presentation is ready for display. There is a tactile display in the room or she can use her personal tactile display. The tactile display has a copy of the presentation plus additional control functions (active functions), pointing facilities and control of slide content details. In AmI, the wide availability of tactile displays is part of the built-in virtual reality interfaces. Otherwise the presentation can be controlled using a gesture recognition system. If Maria is not able to hear, but is able to speak, she does not have problems for the presentation. Otherwise she can use a speech synthesizer (see Dimitrios scenario). During the discussion, a speech recognition system is used. She can type answers to be read or synthesised. Alternatively, she can use sign language, translated into voice in real time.

Dimitrios' physical environment is not described in any way. It is the only scenario in which some incongruence is present. Dimitrios has a very advanced D-Me system, that according to the script is "equipped with voice, pattern and patch recognition capacity. It has to identify places and people, but also to register enough data to record the relevant events of Dimitrios' life to process it in its D-Me profile and offer it to other D-Me's". Then, in AmI there is an abundance of screens (real and virtual) and audio communication channels. Any surface, in principle, can become a screen, both because of the smart material of which it is made and because images are projected on it. But when Dimitrios needs to speak with his wife, he has to move to a displayphone, a device coming from the prehistory of telecommunications. However, such a displayphone can use all the capabilities of AmI. If Dimitrios cannot see, the displayphone is able to describe any drawing eventually present on the screen. On the other hand, if Dimitrios cannot hear, it can convert his wife's voice into text. It is obviously able to convert sign-language to voice (probably supported by the D-Me, in this case playing an ancillary role) or can be used as a simple text telephone. Correspondingly, the output of a speech recogniser can be translated to lip movements and/or sign languages. If Dimitrios cannot speak and does not know sign language, he can use a (virtual) keyboard and a prediction system. If Dimitrios has cognitive problems, the displayphone can adapt itself to his preferences and mimic the functionalities and interface of a system he is normally using. The complexity of the displayphone (functions, tasks to be carried out to use it, etc.) can be matched to Dimitrios' capabilities. Support is automatically given if necessary.

Interactive simulation and projection facilities are enhanced not only regarding technical performance (for example 3D presentations), but also regarding their capability of adaptation to the needs of the users, both guiding them through the tasks needed for presentation and tailoring performance to the complexity of the required presentation. Nowadays, interactive simulation systems are inherently based on interaction paradigms using direct manipulation of objects and on complex (also three-dimensional) visual presentations. In the AmI environment, the system will have evolved to be multimedia and multimodal. For example, a possible solution for a person who cannot see could be the evolution toward a virtual reality system based on sound and tactile interactions (tactile exploration of virtual objects both for input and output of data). The new technology developed for the implementation of the intelligent environment (e.g., tactile display technology, virtual reality, tactile input technology) can contribute to an easier access to information by people who cannot see.

When Maria arrives in the airport of a far away country, she is relieved by the fact that she can travel with hand baggage only, because everything she needs for interacting with the information and communication environment is the P-Com. She does not need any computer or terminal. Computing power is available everywhere, along with suitable peripherals for interacting with it. Even if not all people going around need complex systems as the ones necessary to Maria for giving her business presentation, any simplification in the type and complexity of necessary devices can be particularly useful for many user groups (for example, people with spastic cerebral palsy and people moving in a wheelchair).

However, some people may prefer a *personalised system*. For example, if Maria cannot see, her P-com can be equipped with a specialised interface (e.g., a foldable tactile interface). Even if tactile presentations are in principle available for all users, she prefers to carry her own device so as to avoid potential problems during her trip. When necessary, the P-com can communicate with sophisticated peripherals (e.g., a tactile 3-D system) available in the environment. When going through the airport, she can be guided by the environment to avoid unexpected obstacles (for example a piece of baggage left unattended). Alternatively she can use a personal system (e.g., a virtual guide dog). RFID on objects can be used for signalling the presence of obstacles to the virtual guide dog.

When navigating in the airport, if Maria cannot see or has fixation problems, information is conveyed using the speech channel of the P-Com, whereas, if she cannot hear, information is presented through text or maps (for example, on a visual display embedded in her spectacles). If Maria has cognitive problems, the single tasks to be performed can be conveyed though her preferred modality and explained in details. If necessary, she can be put under control of a relative or a service centre to follow her way through the airport and help and reassure her if she has difficulties.

5.4.4. Emerging challenges

In reading the previous sections, one could be led to conclude that the information society offers a panacea for the problems of people with disabilities. However, before arriving at such a conclusion, some challenges need to be addressed.

The first challenge is related to the intelligence that is considered as an integral part of the emerging environment. Considering the current state of the art in Artificial Intelligence, it is clear that significant improvements are needed in order to realize the environment foreseen in the ISTAG scenarios. For example, even if speech recognition and speech synthesis are improving, the introduction of intonation in synthetic speech, the recognition of speech outside specialist domains, and the translation between different languages require fundamental improvements in the semantic interpretation of messages. The same is true for those aspects of the intelligent environment that are related to people’s emotions or difficulties in executing tasks. Obviously, without fundamental improvements with respect to present possibilities, the environment could interfere in the life of citizens in unacceptable and negative ways.

Second, it must be considered that the analysis presented above is related only to problems of access to information and communication and to other activities that can be supported by improving the possibility of being integrated into the information and communication community. This will obviously not solve all the problems of people, and in any case needs a proactive Design for All approach in order to take full advantage of new possibilities. For example, having speech synthesis or transitory Braille displays as a standard feature of the environment does not automatically mean that all information will be available to people who cannot see, because this will depend on how the information is stored and structured. Since it is clearly impossible to adapt all the databases connected to the network, it will be necessary to use a Design for All approach (for example, the WAI guidelines) to represent information in a form that is amenable to a “transduction” using text (speech or Braille). But this is not sufficient. For example, if information about accessibility is not available in a hotel database, no guideline regarding the representation of information and no adaptation will help.

This applies to the development of all the technologies foreseen in the scenarios, which must have embedded all the characteristics necessary for the inclusion of all potential users. Gesture recognition is considered as a very important technology, but additional research efforts are necessary in order to be able to extract information from a spastic movement. Speech recognition can be very important for interfacing with the environment for people who cannot use a keyboard or a pointing device, but the training system must be robust enough to accept not only “standard” voices, but, for example, voices of people with cerebral palsy.

Translation between different languages has the potential of eliminating the barrier among different countries, languages and cultures, but, obviously, the level of inclusion will depend on the languages that are considered. For example, different sign languages and symbolic languages (such as Bliss) will need to be part of the set of considered languages.

Many other aspects of the development of an intelligent environment must be discussed as to their impact on the population at large and on people with disabilities in particular. First of all, it is necessary to investigate how human functions will be engaged in the emerging forms of interaction and how this interaction will affect individual perceptive and cognitive spaces. The emerging environment may be very complex and stimulating, from both a sensorial and cognitive perspective. It is not clear whether people will be able to cope with the hyper-stimulation and the corresponding cognitive load. This is particularly true for people with reduced abilities, and principally for people with cognitive limitations. The environment must be developed in such a way that the capabilities of people are taken into account, for example, in order to balance the distribution of tasks between the user and the intelligent environment itself.

This introduces another very important aspect. The acceptance of the new environment by the citizens will also depend on their trust in it and, therefore, on their level of acceptance of delegation. This may be a particularly sensitive point for people with disabilities, who might need to delegate more than other users and have additional problems in conceptualising the situation. Therefore, the environment must both incorporate all the adaptation and personalisation facilities needed by all the groups of potential users, as well as provide to users the possibility to really understand the facilities available and the implications of delegating certain tasks to the intelligent environment.

Impact on emotion, vigilance, information processing and memory must be considered with particular attention when people with disabilities are involved. On a lower level, it is necessary to avoid forms of interaction that may lead to negative consequences such as confusion, cognitive overload, and frustration. This, for example, requires a distribution of input/output facilities in the environment that is continuous, in order not to create frustration or confusion, flexible, so as to adapt itself to the different contexts of use, and coherent throughout the environment. This is a particularly important characteristic, because the fact that the interaction maintains an internal coherence in every situation will obviously facilitate interaction and favour acceptance. It is also important, when different modalities and, therefore, different sensorial channels, are used. It is essential that the requirements of users with activity limitations are taken into account, because the optimisation of information transfer is more critical for them.

Another challenge involves privacy and security. The possibility of adapting the environment to different types of users requires the availability of information about them. In the case of people with disabilities, this information may be very sensitive. It is therefore of paramount importance that users can trust the privacy guaranteed by the system. Privacy has always been a very important problem in any control system. The problem is made more sensitive now by the fact that the control will not be affected by a dedicated system, but by an omnipresent intelligent environment.

Lastly, security is another very import aspect. The intelligent environment, including also the support infrastructure, is a very complex system. It has recently been demonstrated that complex systems are prone to collapse (electrical blackouts due to the collapse of the distribution system are a well-known example). This could be very dangerous if human society is organised around a complex information and communication system such as the one envisaged in the AmI scenarios. This has particularly importance for people with disabilities, who will rely more heavily on the available facilities. Therefore, backup strategies, redundancy and error checking facilities will have to be available in the system and must be understandable by end users.

5.5. Intelligence in Ambient Intelligence environments

5.5.1. Introduction

While most problems for inclusion within the present Information Society are connected with a suitable structuring of information and an accessible interface of users with the system (including an appropriate use of different modalities), inclusion within the Ambient Intelligence environment is much more complex because of the multiplicity and heterogeneity of intelligent objects in the environment, the variety of contexts of use, and the diversity of user goals.

The main purpose of this section is to discuss the meaning and role of "intelligence" in the emerging environment, by arguing that up to now the main emphasis of the development activity has been more in the "ambient" aspects of the emerging environment that is in the intelligent objects, their interconnection, and their interfacing (Coroama, 2006; Richter and Hellenschmidt, 2004; Johanson et al., 2003; Garlan and al. 2002), than in the intelligence of the environment as such, needed for identifying the goals of the users, how the goals become modified in different contexts and how AmI can contribute to their fulfilment in a way that is acceptable and accessible by the users. Correspondingly, Design for All approaches that have been developed to make Information and Communication Technologies (ICT) systems and services and their interfaces accessible to all potential users need a revision and generalization at the technical approach level, in order to cope with emerging accessibility problems.

5.5.2. Design for All in AmI scenarios

The situation is very complex if an instantiation of the information society as the one sketched in Chapter 2 is taken into account. In fact, the information society is no longer seen as a support to the execution of activities such as accessing and manipulating information or communicating with other people, but is supposed to have an impact on all aspects of our social activities. This is clear if the socio-political factors at the basis of the deployment of the new technology and application environments as discussed in the ISTAG documents are considered[78].

It is clear from the AmI design requirements reported in Chapter 2 that Design for All in the information society must be much more than personalisation (adaptability) and adaptivity, which however are among the required features of AmI. Smart devices and (complex) services are supposed to be embedded in the environment, and must be able to provide support to users only when they need them, anticipating their desires. Moreover, this must occur in any place and context of use and in any moment. This requires the deployment of an infrastructure for supporting ubiquitous connection and

[78] See ISTAG web page at http://cordis.europa.eu/ist/istag.htm

computational power, but also of intelligence for identifying the goals of the users and helping users in fulfilling them. Therefore, the environment must not only be filled with intelligent objects (that is, computer-based systems), but must also be able to reason with regard to the goals of the users and to optimise the support in accordance with the resources available.

From this perspective, it is interesting to report some of the comments that ISTAG experts offer concerning the intelligence present in the environment (Ducatel, 2001). For the Maria scenario, they report that the intelligence is in the seamless and intuitive support that Maria has as she goes around in her high-pressure world. She does not have to negotiate each step of her trip, because intelligent agents take care of most practical arrangements, even if she is always in control. This allows her to concentrate on the real purpose of her trip, in this case making her presentation. In the Dimitrios scenario, the system must have a lot of intelligence. It must capture, process and share data about humans' lives by constructing and managing knowledge databases, while most of decision are made by agents. The seamless intercommunication of devices will generate a permanent and invisible data flow. The real role of AmI here is to expand human relationships. Mass consumption of D-Me's will create the possibility of people-based, ad-hoc networks that protect people from unwarranted interference in their lives and provide possibilities of making new contacts and interactions. It is supposed to develop a continuously changing virtual space in which amounts of virtual relations develop. Here, it is important to observe the complexity of the privacy and security problems in this environment as regards the criticality of the information to be used (database of a human's life) and the complexity of the virtual environment foreseen. Reasoning about decisions connected with the exchange or withdrawal of critical information will be of paramount importance as far as acceptance is concerned. For Carmen, the AmI approach leads to a much more efficient and user-friendly urban environment. It tries to optimise among the competing goals (e.g. individual preferences versus the good of the population) for the use of the urban space. This involves the operation of very large-scale systems, and requires societal acceptance of the legitimacy of the results (i.e. automated speed controls). Lastly, for Annette and Solomon the role of the AmI environment is to permit greater empowerment of users - starting with mentors and students - over their own tasks and processes in a learning environment. The system provides instant feedback on many different issues, which does not result from rule-based systems, but from the ability to record and review (if possible, quite literally) experiences of past and present participants. Moreover, technologies capable of supporting social (learning) processes must be deployed. The system starts with the simple provision of a network for communication and a collective corporate memory, on which gradually many different kinds of new applications can be built and to which new technological possibilities can be added. Therefore, it can be concluded that a lot of intelligence is necessary in the system in addition to what is needed to make systems and services adaptable and adaptive to the needs of the users.

5.5.3. Levels of necessary intelligence

While many problems connected with interaction with the present Information Society are actually linked to a suitable structuring of information and an accessible human system interface, integration within the Ambient Intelligence environment is much more complex, due to the interplay of different levels, e.g. the physical level with a multiplicity and heterogeneity of intelligent objects in the environment and their need for a continuous and high-speed connection, the level of identification and consideration of the variety of contexts of use, and the level of elicitation of the diversity of user goals and help in their fulfilment.

The system (intelligent ambient environment) must be able to seamlessly integrate the three levels considered above. At the lower level, all objects in the environment must incorporate intelligence and must be interconnected and able to cooperate in order to support the goals of the user. Moreover, the environment must be reconfigurable in real time, to cater for the introduction or removal of components (for example, objects that users entering the environment may have with them), by remodelling its support as a function of the available resources. This aspect of the intelligent environment is a prerequisite for its development, and the reconfiguration must take into account the variability of the contexts of use and the goals of the users.

At this level, artificial intelligence is crucial in supporting the development of basic technologies considered important in the implementation of AmI. For example, the ISTAG experts write that pattern recognition (including speech and gesture) is a key area of artificial intelligence which is already evolving rapidly. Speech recognition will have a big impact on the miniaturisation of devices and the augmentation of objects allowing hands-free operation of personal ambient devices. In the scenarios, the use of voice, gesture and automatic identification and localisation are implicitly used to synchronise systems, so that services are available when people want them. The synchronization of systems is indeed a very important aspect. In the intelligent environment, there may be different users with goals that have different importance and criticality. AmI must be able to decide how to take care of potentially conflicting needs (from the perspective of resources).

At a higher level, the AmI environment must take care of the contexts of use considered as processes, which are defined by specific sets of situations, roles, relations, and entities (Coutaz, 2005). Recently, interest on the right definition and role of the contexts of use has grown, when dealing with both the development of user machine interfaces and with the organization and representation of information. For example, in connection with multimodality, it has been argued that the availability of different representations of the same information could be very interesting in order to avoid problems of context-related accessibility. Typical examples are car drivers who are functionally blind and motor disabled, meaning that they cannot interact with information and communication by using a screen and a pointer. But in AmI, the situation is more complex, because in the ubiquitous interaction with information and telecommunication systems the context of use may change continuously or abruptly and the same systems or services may need to behave differently in different contexts

When discussing the technology necessary for transforming the scenarios into reality, ISTAG experts (ISTAG, 2003) make a list of its intelligent components. They are:

- Media management and handling, including presentation languages that support “produce once” and “present anywhere”, methods and tools to analyse content and enrich it with metadata, and tools for exploiting the Semantic Web;
- Natural interaction that combines speech, vision, gesture, and facial expression into a truly integrated multimodal interaction concept, that allows human beings to interact with virtual worlds through physical objects, and that enables people to navigate the seemingly infinite information which they will be able to access;
- Computational intelligence, including conversational search and dialogue systems, behavioural systems that can adapt to human behaviour, and computational methods to support complex search and planning tasks;
- Contextual awareness, for instance, systems that support navigation in public environments, e.g. in traffic, in airports and in hospitals, service discovery systems that enhance the shopping experience, and context-aware control and surveillance systems;
- Emotional computing that models or embodies emotions in the computer, and systems that can respond to or recognise the moods of their users, and systems that can express emotions.

The above technologies are the necessary building blocks for implementing AmI environments populated by smart artefacts that can adapt to human behaviour and to different contexts. The question now is whether the list is exhaustive and what the impact of (artificial) intelligence is in really meeting the design requirements. That is, creating an environment where people can reach their goals and which they do not feel as artificial does not create problems of information overload and confusion, and is perceived as being worthy of trust and confidence.

Indeed, in addition to objects and contexts of use, there is a higher abstraction level to be considered. Most of the interaction with currently available systems is based on the performance of tasks in a set determined by the application used. In the intelligent environment, the goals of the user are the starting point. They must be inferred by the system and decomposed into tasks that are adapted to the preferences of the individual. This is really the level where intelligence plays a crucial role. The acceptability and uptake of the new paradigm will be essentially dependent on how smart the system is in inferring the goals of the users in the continuously varying contexts of use and in organising the available resources (intelligent objects in the environment) in order to help users to fulfil them. Moreover, this aspect is also very sensitive from a psychological perspective. For example, the system must be able to f infer the goals of the users without giving them the impression that they are under control (big brother), and must be able to support the users without giving them the impression that they are forcing them. It must “offer” possible solutions, not “impose” them. This requires a lot of ingenuity also on the part of human beings, and appears particularly difficult for a machine. However, it can also be argued that the intelligence in the system does not necessarily have to be artificial, but could and probably will also be in the network of interconnected and cooperating persons.

5.5.4. An example: Annette and Solomon

In order to clarify the main points made above, let us now briefly discuss one of the ISTAG scenarios (that of Annette and Solomon). In the following discussion, it is taken for granted that the environment is completely functional from a technical point of view: i.e. it includes all intelligent objects necessary for carrying out the foreseen activities (sensors to monitor people’s behaviour, actuators for suitably re-structuring the space, presentation systems); all the objects are interconnected through a broadband network that guarantees the necessary exchange of information, and suitable natural interaction systems are deployed. The focus is on the “intelligence” necessary, in addition to an efficient network of intelligent objects and natural interfaces, for making the scenario suitable for attaining the results described. Here as follows, the parts in italics report the scenario as described in the ISTAG document.

It is the plenary meeting of an environmental studies group in a local ‘Ambient for Social Learning’. The group ranges from 10 to 75 years old. They share a common desire to understand the environment and environmental management. It is led by a mentor whose role it is to guide and facilitate the group’s operation, but who is not necessarily very knowledgeable about environmental management. The plenary takes place in a room looking much like a hotel foyer with comfortable furniture pleasantly arranged. The meeting is open from 7.00-23.00 hours. Most participants are there for 4-6 hours. A large group arrives around 9.30 a.m. Some are scheduled to work together in real time and space and thus were requested to be present together (the ambient accesses their agendas to do the scheduling).

One of the complexities of this scenario has to do with the fact that it addresses a group, and not an individual. Therefore, the mentor and the ambient must be able to control both the group dynamics and the learning activity. This is why a mentor is considered necessary. S/he is not an expert in the topic to be learned. Therefore, her/his main role is apparently to work at the level of the group dynamics, while the organisation of the learning itself is mainly delegated to the AmI environment, to the group of learners, and to external experts. Additional difficulties lie in the fact that the group is not homogeneous (it includes people aged from 10 to 75 years). Obviously, the members have a different general culture, knowledge of the topic, interests, speed of learning, etc. Also, the group composition changes randomly with time, even if there are some scheduled meetings. Lastly, the space is not structured, and people can seemingly move around while the space is restructured in order to meet the needs of groups and individuals.

Therefore, the ambient must: (i) be acquainted with the topic to be taught and be able to organise it at the level of complexity suitable for the individual users, if and when they are studying individually, as a function of the user’s present knowledge and culture and the goal(s) of the learning activity; (ii) know the individual users, and be able to follow them during their movements in the learning space; (iii) organise the common work on the basis of the goal(s) to be attained and the people who are in the group; (iv) reorganise the work when new persons are added to the group or leave it; (v) restructure the space as a function of the different groups that dynamically form it by making the necessary resources available; (vi) not interfere with the group dynamics. It must monitor the behaviour of individuals and the group, and support the mentor in her activity. This means that the ambient must understand what the mentor is doing, be able to reason with regard to the situation of the group, and behave accordingly.

A member is arriving: as she enters the room and finds herself a place to work, she hears a familiar voice asking "Hello Annette, I got the assignment you did last night from home: are you satisfied with the results?" Annette answers that she was happy with her strategy for managing forests provided that she had got the climatic model right: she was less sure of this. Annette is an active and advanced student so the ambient says it might be useful if Annette spends some time today trying to pin down the problem with the model using enhanced interactive simulation and projection facilities. It then asks if Annette would give a brief presentation to the group. The ambient goes briefly through its understanding of Annette's availability and preferences for the day's work. Finally, Annette agrees on her work programme for the day.

This introduces a new level of difficulty, because the ambient must not only be able to organise the learning material according to preset schemes, but must "understand" it as well, because it discusses the correctness of the work done by Annette and suggests how to clarify the controversial points.

One particularly long conversation takes place with Solomon who has just moved to the area and joined the group. The ambient establishes Solomon's identity; asks Solomon for the name of an ambient that 'knows' Solomon; gets permission from Solomon to acquire information about Solomon's background and experience in Environmental Studies. The ambient then suggests Solomon to join the meeting and to introduce himself to the group. In these private conversations the mental states of the group are synchronised with the ambient, individual and collective work plans are agreed and in most cases checked with the mentor through the ambient. In some cases the assistance of the mentor is requested.

Even if it is not clear what "the mental state of the group are synchronised with the ambient" means and what the roles of the ambient and the mentor are, this probably implies a level of abstraction that is not compatible with suitable organisations of intelligent objects.

A scheduled plenary meeting begins with those who are present. Solomon introduces himself. Annette gives a 3-D presentation of her assignment. A group member asks questions about one of Annette's decisions and alternative visualisations are projected. During the presentation the mentor is feeding observations and questions to the ambient, together with William, an expert who was asked to join the meeting. William, although several thousand miles away, joins to make a comment and answer some questions. The session ends with a discussion of how Annette's work contributes to that of the others and the proposal of schedules for the remainder of the day. The ambient suggests a schedule involving both shared and individual sessions.

Again, the ambient is able to understand the problem under discussion and plan the work accordingly, as it is also able to segment it in individual and shared sessions. This implies an estimation of the individual's pace of learning and a careful planning for synchronising the individual sessions with the shared ones.

During the day individuals and sub-groups locate in appropriate spaces in the ambient to pursue appropriate learning experiences at a pace that suits them. The ambient negotiates its degree of participation in these experiences with the aid of the mentor. During the day the mentor and ambient converse frequently, establishing where the mentor might most usefully spend his time, and in some cases altering the schedule. The ambient and the mentor will spend some time negotiating shared experiences with other ambients – for example mounting a single musical concert with players from two or more distant sites. They will also deal with requests for references / profiles of individuals. Time spent in the ambient ends by negotiating a homework assignment with each individual, but only after they have been informed about what the ambient expects to happen for the rest of the day and making appointments for next day or next time.

This implies a high level of abstraction. The ambient is not a "big brother" that controls the activity of the members of the group and participates in the activities according to the perceived needs of the learning person. It is able to infer their possible difficulties and negotiate its level of participation with the learning person. The learning environment is not a school, but a place where people pursue a learning experience. Therefore, they have the right to learn what, how and when they want. The ambient must understand this, and negotiate with people only if it thinks that it could help in attaining their perceived goal. Moreover, as the mentor's activity is mainly related to the group dynamics, the fact that the mentor and the ambient discuss the matter of where the mentor should spend his/her time implies that the ambient has an understanding of the dynamics within the different groups.

5.5.5. Conclusions

The scenario commented above clearly shows that the usability and usefulness of AmI environments is not exclusively related to the availability of intelligent objects with natural interfaces that are efficiently interconnected through a broadband network and able to adapt themselves to the different contexts of use.

To be acceptable and useful, the AmI environment must be continuously able to obtain information not only about the users, but also about their goals, the space in which people are located, their interpersonal interactions, and the activities to be carried out in order to match the available facilities and support for fulfilling people's goals within the variable contexts of use. This is particularly true when it has to deal with groups of interacting people. Moreover, it must be able to "reason" with regard to people's goals and to their variability as a function of the context and the interaction with other people, in order to structure the activities necessary for attaining the goals in a way that is matched to the capabilities of the people and to the available resources. However, it must not give users the impression that they are controlled; instead, they should believe that they are always in control of the situation, and must have a sense of trust and confidence.

Therefore, the Design for All approach continues to be valid at the conceptual level, or, rather, it is the only reasonable possibility. This is because environments as complex as the emerging ones cannot be designed without taking into account the needs, requirements and preferences of all users. However, the underlying technical approach must be revised because, even if they are important, the concepts of adaptability and adaptivity are not sufficient to satisfy the requirements of complex situations such as the ones described in the Annette and Solomon scenario.

The "quality" and "quantity" of the necessary intelligence and the balance between "natural" and "artificial" intelligence cooperating in the AmI environments is an open challenge at both the conceptual and technical levels.

6. References

Aarts, E. (2004), “Ambient Intelligence: A Multimedia Perspective”, Philips Research.

Aarts, E. & Diederiks, E., ed. (2006), “Ambient Lifestyle: from Concepts to Experiences”, BIS Publishers, Amsterdam.

Aarts, E. & Marzano, S., (2003). “The New Everyday views on Ambient Intelligence”. Rotterdam: OIO Publishers.

Abowd G., Mynatt E., Rodden T., (2002). “The Human experience”. *IEEE Pervasive Computing*, 1 (1), 48-57.

Aftanas, L. I., Reva, N. V., Varlamov, A. A., Pavlov, S. V., Makhnev, V. P. (2004), “Analysis of evoked EEG synchronisation and desynchronisation in conditions of emotional activation in humans: temporal and topographic characteristics”, *Neuroscience and Behavioural Physiology*, 34, 8, 2004.

Akoumianakis D., Stephanidis C. (1997a), “Knowledge-based Support for User-Adapted Interaction Design”, Expert Systems with Applications, vol. 12(2), pp. 225-245.

Akoumianakis, D., Stephanidis, C. (1997b), “Supporting user adapted interface design: The USE-IT system”, International Journal of Interacting with Computers, vol. 9(1), pp. 73-104.

Akoumianakis, D., Savidis, A., Stephanidis, C. (1999), “Encapsulating Intelligent Interactive Behaviour in Unified User Interface Artefacts”, to appear in the International Journal on Interacting with Computers, special issue on “The Reality of Intelligent InterfaceTechnology”, 38 pages.

Aldrich, F.K., (2003), “Smart Homes: Past Present and Future”, In R. Harper (Ed.), “Inside the smart home” (pp. 17- 39), London, Springer- Verlag.

Antòn P. S., Silberglitt R., Schneider J. (2001). “The Globaltechnology Revolution”, Rand, prepared for the National Intelligence Council.

Astell, A. J., Ellis, M., Alm, N., Dye, R, Gowans, G., & Campbell, J. (2002), “Developing computer technology to assist communication for people with dementia: The CIRCA project”, *Neurobiology of Aging*, 23 (1S), S543.

Australian Communications Authority (ACA) (2005), “Vision 20/20: Future Scenarios for the Communications Industry – Implications for Regulation”.

Bargeberger-Gateau, P., Commenges, D., Gagnon, M., Letenneur, L., Sauvel, C. & Dartigues, J. F. (1992), “Instrumental activities of daily living as a screening tool for cognitive impairment and dementia in elderly community dwellers”, *Journal of the American Geriatric Society*, 40, 1129 – 1134.

Billi, M., Burzagli, L., Gabbanini, F., Graziani, P. & Palchetti, E. (2004), ‘The Use of Current Content Management Systems for Accessibility’, in Klaus Miesenberger; Joachim Klaus; Wolfgang Zagler & Arthur Karshmer, ed., “*Computers Helping People with Special Needs*”, Springer, 331-338.

Berners-Lee, T.,, Hendler, J. & Lassila, O. (2001), 'The Semantic Web', *Scientific American*, 34-43.

Bostanov, V., (2003), “Event-related brain potentials in emotion perception research, individual cognitive assessment, and brain-computer interface”, Ph.D. Dissertation, Eberhard-Karls-University, Tubingen, Germany, 2003.

Burzagli, L., Emiliani, P. L. & Gabbanini, F. (2007), “Is the Intelligent Environment Smart Enough?”, *in* Constantine Stephanidis, ed.,”Universal Access in Human-Computer Interaction”, Springer, , pp. 43--52.

Cacioppo, J. T., Tassinary, L.G. (1990), "Inferring psychological significance from physiological signals", *American Psychologist*, 45, 1, Jan. 1990, 16-28.

Carmien, S., (2004), "MAPS: Creating Socio-Technical Environments in Support of Distributed Cognition for People with Cognitive Impairments and Their Caregivers", CHI2004 Proceedings, Vienna 2004.

Chute, D. L., & Bliss, M. E. (1988) "Prosthesis ware: Personal computer support for independent living (Vol. 2000). Retrieved December 16, 2002, from http://www.homemods.org/library/life-span/prosthesis.html

Coroama, V. (2006), "Experiences from the design of a ubiquitous computing system for the blind", In: CHI '06: CHI '06 extended abstracts on Human factors in computing systems, New York, NY, USA, ACM Press, 664-669.

Cowie, R., Douglas-Cowie, E., Tsapatsoulis, N., Votsis, G., Kollias, S., Fellenz, W., Taylor, J.G., (2001), "Emotion recognition in human-computer interaction", *IEEE Signal Processing Magazine*, Jan. 2001, 32-80.

Crowley, J. L., Coutaz, J., Rey, G. & Reignier, P. (2002), "Perceptual Components for Context Aware Computing", in 'UbiComp '02: Proceedings of the 4th international conference on Ubiquitous Computing', Springer-Verlag, London, UK, pp. 117--134.

Coutaz, J.; Crowley, J. L.; Dobson, S. & Garlan, D. (2005), 'Context is key', *Commun. ACM* **48**(3), 49--53.

Danger, S., Huizing, N., Walker, A., Rowland, A., Anderson, R., Sciaccaluga, R., (1996), "EU Information Society Guide", Brussels, Belgium, The EU Committee on the American Chamber of Commerce in Belgium.

Davidson, R. J., Jackson, D. C., Kalin, N. H., (2000), "Emotion, plasticity, context, and regulation: prespectives from affective neurosciences", *Psychological Bulletin*, 126, 6, 2000, 890-909.

Davidson, R. J. (2003), "Affective neuroscience and psychophysiology: toward a synthesis", *Psychophysiology*, 40, Sept. 2003, 655 – 665.

Diaz I., Hernantes J., Gill J. J. (2007), "Combining Sensorial Modalities in Haptic Navigation Tasks for Blind People", Proceedings of the 9th European Conference for the Advancement of Assistive Technology in Europe, AAATE 2007, San Sebastian, Spain, October 2007

Donatell, G. J., Meister, D. W., O'Brien, J. R., Thurlow, J. S., Webster, J. G. and Salvi, F. J. (2005), "A simple device to monitor flexion and lateral bending of the lumbar spine," *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, vol. 13, no. 1, pp. 18-23.

Ducatel, K.; Bogdanowicz, M.; Scapolo, F.; Leijten, J. & Burgelman, J. C. (2001), "Scenarios for Ambient Intelligence in 2010", Technical report, Information Society Technologies Programme of the European Union Commission (IST).

EICTA (2007), "Total Conversation – From Vision to Implementation", EICTA recommendations Brussels.

Ekman P.et al. (1987), "Universals and cultural differences in the judgments of facial expressions of emotion", *Journal of Personality and Social Psychology*, 53, 4, 712-717.

Ellis, J. (1996) "Prospective memory or the realization of delayed intentions: A conceptual framework for research", In M. Brandimonte, G. O. Einstein, & M. A. McDaniel (Eds.), Prospective memory: Theory and applications (pp. 1–22), Mahwah, NJ, Lawrence Erlbaum Associates, Inc.

Emiliani P.L. (2001), "Anyone, Anywhere Access to Community-Oriented Services", 1st International Conference on "Universal Access in Human-Computer Interaction", New Orleans, pp. 803 – 807.

Emiliani, P. L. & Stephanidis, C. (2005), "Universal access to ambient intelligence environments: opportunities and challenges for people with disabilities", *IBM Systems Journal* **44**(3), 605--619.

European SeniorWatch Observatory and Inventory, (2002), “Older People and Information Society”, p. 34.

Estrin D., Culler D., Pister K., Sukhatme G., (2002), “Connecting the Physical world with pervasive Networks”, *IEEE Pervasive Computing*, 1 (1), 59-69.

Fink, J., Kobsa, A., & Nill, A. (1997), “Adaptable and Adaptive Information Access for All Users, Including the Disabled and Elderly”, In A. Jameson, C. Paris, & C. Tasso (Eds.), Proceedings of the 6th International Conference on User Modelling (UM '97), Sardinia, Italy (pp. 171-173), New York: Springer-Verlag.

Friedewald, M. et.al. (ed.), (2006), “Safeguards in a World of Ambient Intelligence (SWAMI)”, Deliverable D1. IST, 6th Framework Programme.

Friedman, M., Kostraba, J., Henry, K., & Coltellaro, J. (1991), “Hardware description of a portable electronic device”, Proceedings of the Rehabilitation Engineering Society of North America (RESNA) (pp. 333-334), Arlington, VA: RESNA Press.

Fujitsu Magazine (2005), “Special Issue on Universal Design”, FUJITSU Sci. Tech. J., 1,1.

Garlan, D., Siewiorek, D., Smailagic, A., Steenkiste, P. (2002), “Project aura: Towards distraction-free pervasive computing”, *IEEE Pervasive computing* 1(2) 22-31.

Geer D., (2004), “Will gesture recognition technology point the way?”, *IEEE Computer*, 37(10), 20-23.

Gill, J. (1996), “Telecommunications: the Missing Links for People with Disabilities”, COST 219, European Commission, Directorate General XIII, Telecommunications, Information Market and Exploration of Research.

Grandjean, D., Sander, D., Pourtois, G., Schwartz, S., Seghier, M. L., Scherer, K. R. and Vuilleumier, P., (2005), "The voices of wrath: brain responses to angry prosody in meaningless speech", *Nature Neuroscience* 8, 2005, 145 - 146.

Gregor, P., & Newell, A. F. (2000), “An empirical investigation of ways in which some of the problems encountered by some dyslexics may be alleviated using computer techniques”, Proceedings of Assets 2000 “The Fourth International ACM Conference on Assistive Technologies”, Washington, DC (pp. 85-91), New York: ACM Press.

Gutiérrez J.A., Gonzáes F.J., Picón A., Isasi A., Dominguez A., Idigoras I. (2007), “Electronic Display Panel Mobile Reader”, Proceedings of the 9th European Conference for the “Advancement of Assistive Technology in Europe”, AAATE 2007, San Sebastian, Spain, October 2007.

Hampicke, M., (2000), “Smart Home: Speech Based User Interfaces for Smart Home Applications“, COST219bis Seminar “Speech and Hearing Technology”,Cottbus, Germany.

Hawley M., Cunningham S., Cardinaux F., Coy A., O'Neill P., Seghal S., Enderby P. (2007), “Challenges in developing a Voice Input Voice Output Communication Aid for People with Severe Dysarthria”, Proceedings of the 9th European Conference for the “Advancement of Assistive Technology in Europe”, AAATE 2007, San Sebastian, Spain, October 2007.

Howard-Spink, S. (2002) “You just don't understand!”, Retrieved October 24, 2006 from http://domino.watson.ibm.com/comm/wwwr_thinkresearch.nsf/pages/20020918_speech.html

IMS (2002), “Guidelines for Developing Accessible Learning Applications”.

iRv (2000), “Price Partnership Ltd, Study on Technology Trends and Future Perspectives within Assistive Technologies”, Final Report, october 2000

IST results, (2006), “Help for elderly people to spark new research ideas”, AAL, Berlin.

ISTAG (2003), “Ambient Intelligence: from vision to reality. For participation in society and business”, Information Society Technologies Programme of the European Union Commission (IST).

Johansen, A. S., Hansen, J. P. (2006), "Augmentative and alternative communication: the future of text on the move", *International Journal Universal Access in the Information Society,* Vol. 5 N. 2, pp 125-149, Springer.

Johanson, B., Winograd, T., Fox, A. (2003), "Interactive workspaces", *Computer*, 36(4), 99-101.

Katz, S. Down, T.D. & Cash, H. R. (1970), "Progress in the development of the Index of ADL", *Gerontologist*, 10, 20 – 30.

Kielhofner, G. (1997), "The sensory integration model", In G. Kielhofner (Ed.), "Conceptual foundations of occupational therapy" (pp. 251–269), Philadelphia, PA: F.A. Davis Company.

Knights, M. (2007), "Web 2.0", *Communications Enginee,r* **5**(1), 30-35.

Kobsa, A., & Pohl, W. (1995), "The user modelling shell system BGP-MS", *User Modelling and User-adapted interaction*, 4 (2), 59-106.

Korhonen, I., Parkka, J., Van Gils, M., (2003), "Health monitoring in the home of the future", *IEEE Eng Med Biol Mag*. 22 (3): 66-73.

Kouroupetroglou G., Viglas C., Anagnostopoulos A., Stamatis C., Pentaris F., (1996), "A novel Software Architecture for Computer-based Interpersonal Communication aids", In the proceedings of 5th ICCHP'96 "International Conference on Computers and Handicapped People", Linz, Austria, pp. 715-720.

Kurzweil, R. (2001), "The law of accelerating returns", Retrieved October 24, 2006 from http://www.kurzweilai.net/meme/frame.html?main=/articles/art0134.html

Lancioni, G., O'Reilly, M., Seedhouse, P., Furniss, F., & Cunha, B. (2000), "Promoting independent task performance by persons with severe developmental disabilities through a new computer-aided system", *Behavior Modification*, 24(5), 700-718.

Lawton , M. P. & Brody, E. M. (1969), "Assessment of older people: Self maintaining and instrumental activities of daily living", *Gerontologist*, 9, 179 – 186.

Levinson, R. (1997), "PEAT: The planning and execution assistant and training system", *Journal of Head Trauma Rehabilitation*, 12(2), 769-775.

Lewis C. and Rieman J. (1993), ''Task-Centred User InterfaceDesign: A Practical Introduction,'' http://hcibib.org/tcuid/

Lin, K. (2007), "Building Web 2.0", *Computer* **40**(5), 101-102.

Lindströmin, J. (2007), "Safe navigation with wireless technology", in "Towards an inclusive future", P. R.W. Roe ed., Published by COST, Brussels, 2007 pp 9-23.

Lisetti, C. L. and Nasoz, F., (2004), "Using non-invasive wearable computers to recognize human emotions from physiological signals", EURASIP J. Applied Signal Processing, 11, 2004, 1672-1687.

LoPresti, E. F., Mihailidis, A., Kirsch, N., (2004), "Assistive technology for cognitive rehabilitation: State of the art", *Neuropsychological Rehabilitation*, 2004, 14 (1/2), 5-39, Psychology Press.

Lorincz, K., Malan, D., Fulford-Jones, T., Nawoj, A., Clavel, A., Shnayder, V., Mainland, G., Welsh, M., Moulton, S., (2004), "Sensor Networks for Emergency Response:Challenges and Opportunities", *IEEE Pervasive Computing*, 3(4), 16-22.

Morandell, M., Fugger, E., Prazak, B. (2007), "The Alzheimer Avatar - Caregivers' Faces Used as GUI Component", Proceedings of the 9th European Conference for the "Advancement of Assistive Technology in Europe", AAATE 2007, San Sebastian, Spain.

Mueller, M. J., Wharton, C., McIver, W. J., Kaux, L. (1997), "Towards an HCI Research and Practice Agenda Based on Human Needs and Social Responsibility", In the proceedings of ACM Conference on Human Factors in Computing Systems (CHI'97), Atlanta GA, USA.

Murugesan, S. (2007), "Understanding Web 2.0", *IT Professional* **9**(4), 34-41.

Mynatt, E. D., Weber, G. (1994), "Nonvisual presentation of graphical user interfaces: contrasting two approaches", in the Proceedings of the ACM Conference on "Human Factors in Computing Systems" (CHI '94) (pp. 166-172), Boston, Massachusetts, USA, New York: ACM Press.

Nagarajan, S. S., Wang, X., Merzenich, M. M., Schreiner, C. E., Johnston, P., Jenkins, P., Miller, S., & Tallal, P. (1998), "Speech modifications algorithms used for training language learning-impaired children", *IEEE Trans on Rehabilitation Engineering*, 6(3), 257-268.

National Council on Disability, Vaughn, J. (Chairperson) (2006), "Over the Horizon: Potential Impact of Emerging Trends in Information and Communication Technology on Disability Policy and Practice", Technical report, Washington.

NIST, National Institute of Standard and Technology, USA (2008), "Ubiquitous Computing Framework", http://www.itl.nist.gov/iad/vvrg/newweb/ubiq/framework.html

OECD Factbook 2005, (2005), "Economic, Environmental and Social Statistics", OECD, Paris.

Paradiso, R., Loriga, G., and Taccini, N., (2005), "A wearable health care system based on knitted integrated sensors" *IEEE Transactions on Information Technology in Biomedicine*, vol. 9, no. 3, pp. 337-344.

Park S., and Jayaraman, S. (2003), "Enhancing the quality of lift through wearable technology," *IEEE Engineering in Medicine and Biology Magazine*, pp. 41-48.

Park, D. C. (2000), "The basic mechanisms accounting for age-related decline in cognitive function", in Park, D. & Schwarz, N. (Eds.) "Cognitive Aging: A Primer", 3 – 19, Philadelphia: Psychology Press.

Pentland, A. (2004), "Healthwear: medical technology becomes wearable," *IEEE Computer*, pp. 42-49, May.

Petrie, H., Morley, S., McNally, P., O'Neill, A-M., Majoe, D. (1997), "Initial design and evaluation of an interface to hypermedia systems for blind users", In the Proceedings of "Hypertext97", Southampton, UK, pp. 48-56, New York: ACM Press.

O'Reilly, T. (2006), "Web 2.0 Compact Definition: Trying Again", retrieved on 2008-12-18 from http://radar.oreilly.com/archives/2006/12/web_20_compact.html.

O'Reilly, T. (2005), "What Is Web 2.0", O'Reilly Network, retrieved on 2008-12-18 from http://www.oreillynet.com/pub/a/oreilly/tim/news/2005/09/30/what-is-web-20.html.

Richter, K., Hellenschmidt, M. (2004), "Position paper: Interacting with the ambience: Multimodal interaction and Ambient Intelligence", in: W3CWorkshop on "Multimodal Interaction",Sophia Antipolis, France.

Roe, P. Ed. (2006), "Towards an Inclusive Future: Impact and Wider Potential of Information and Communication Technologies", COST, Brussels.

Rolls, E.T. (2000), "Précis of The brain and emotion", *Behavorial and Brain sciences*, 23, 2000, 177-234.

Ross, P. E. (2004), "Managing care through the air", *IEEE Spectrum*, pp. 26-31.

Sandström, G., Gustavsson, S., Lundberg, S., Keijer, U. & Junestrand, S., (2005), "Long-term viability of smart home systems – Business modeling and conceptual requirements on technology", presented at "Home-oriented Informatics and Telematics" (HOIT) 2005 Conference, York University, UK.

Savidis, A., Stephanidis, C. (1995a), "Developing Dual User Interfaces for Integrating Blind and Sighted Users: the HOMER UIMS", 1995 ACM Conference on "Human Factors in Computing Systems" (CHI '95), Denver, USA, pp. 106-113.

Savidis, A., Stephanidis, C. (1995b), “Building non-visual interaction through the development of the Rooms metaphor”, 1995 ACM Conference on “Human Factors in Computing Systems” (CHI '95), Denver, USA, pp. 244-245 (Companion Proceedings).

Savidis, A., Stephanidis, C., Korte, A., Krispien, K., Fellbaum, K. (1996), “A Generic Direct Manipulation in 3d-Auditory Environment for Hierarchical Navigation in Non-Visual Interaction”, 2nd ACM-SIGCAPH Conference on “Assistive Technologies” (ASSETS '96), Vancouver, Canada, pp. 117-123.

Savidis, A., Stephanidis, C., Akoumianakis, D. (1997), “Unifying Toolkit Programming Layers: a Multi-Purpose Toolkit Integration Module”, 4th Eurographics Workshop on “Design, Specification and Verification of Interactive Systems” (DSV-IS '97), Granada, Spain, pp 177-192.

Savidis, A., Stephanidis, C., (1997b), “Agent Classes for Managing Dialogue Control Specification Complexity: A Declarative Language Framework”, HCI International '97, San Francisco, USA, pp. 461-464.

Savidis, A., Stephanidis, C. (1998), “The HOMER UIMS for Dual User Interface Development: Fusing Visual and Non-visual Interactions”, *International Journal of Interacting with Computers*.

Savidis, A., Stephanidis, C. (1998b), “The HOMER UIMS for Dual User Interface Development: Fusing Visual and Non-visual Interactions”, *International Journal of Interacting with Computers*.

Savidis, A., Stergiou, A., Stephanidis, C., (1997) “Generic containers for metaphor fusion in non-visual interaction: The HAWK Interface toolkit”, in the Proceedings of the “Interfaces '97” Conference, Montpellier, France,, pp. 194-196.

Savidis, A., Vernardos, G., Stephanidis, C. (1997), “Embedding Scanning Techniques Accessible to Motor-Impaired Users in the WINDOWS Object Library”, HCI International '97, San Francisco, USA, pp. 429-432.

Savidis, A., Akoumianakis, D., & Stephanidis, C. (2001), “The Unified User Interface Design Method”, in Stephanidis, C. (ed.), “User Interfaces for All”, Lawrence Erlbaum, ISBN 0-8058-2967-9.

Schurmann, M, Caetano, G, Hlushchuk, Y, Jousmaki, V, Hari, R (2006). “Touch activates human auditory cortex”, *Neuroimage*, 30:1325–1331.

Shadbolt, N.; Hall, W. & Berners-Lee, T. (2006), “The semantic Web revisited”, *Intelligent Systems* **21**(3), 96-101.

Soumo, Ministry of Internal Affairs and Communications, Japan (2004), “White Paper 2004”. http://www.soumu.go.jp/english/index.html

Soumo, Ministry of Internal Affairs and Communications, Japan (2005), “White Paper 2005”. http://www.soumu.go.jp/english/index.html

Soumo, Ministry of Internal Affairs and Communications, Japan (2006), “White Paper 2006”. http://www.soumu.go.jp/english/index.html

Soumo, Ministry of Internal Affairs and Communications, Japan. (2007), “White Paper 2004”. http://www.soumu.go.jp/english/index.html

Steg, H., Strese, H., Loroff, C., Hull. J, & Schmidt, S., (2006), “Europe is facing a demographic challenge. Ambient assisted living offers solutions”, Report compiled within the Specific Support Action “Ambient Assisted Living – preparation of an article 169-initiative”, Berlin.

Stephanidis, C., Savidis, A., Akoumianakis, D., (1995), “Tools for User Interfaces for all”, 2nd TIDE Congress, Brussels, Belgium, pp. 167-170.

Stephanidis, C. (1995a), “Towards User Interfaces for All: Some Critical Issues”, HCI International '95, Panel Session “User Interfaces for All - Everybody, Everywhere, and Anytime”, Tokyo, Japan, pp. 137-142.

Stephanidis, C., Mitsopoulos, Y. (1995), “INTERACT: An interface builder facilitating access to users with disabilities”, HCI International '95, Tokyo, Japan,, pp. 923-928.

Stephanidis, C., Savidis, A., Akoumianakis, D. (1997), “Unified Interface Development: Tools for Constructing Accessible and Usable User Interfaces”, Tutorial Notes 13, 7th International Conference on “Human-Computer Interaction” (HCI International ’97), San Francisco, California, USA.

Stephanidis, C., Paramythis, A., Akoumianakis, D., & Sfyrakis, M. (1998), “Self-Adapting Web-based Systems: Towards Universal Accessibility”, 4th ERCIM Workshop on "User Interfaces for All", Stockholm, Sweden, 17 pages.

Stephanidis, C., Salvendy, G., Akoumianakis, D., Bevan, N., Brewer, J., Emiliani, P. L., Galetsas, A., Haataja, S., Iakovidis, I., Jacko, J., Jenkins, P., Karshmer, A., Korn, P., Marcus, A., Murphy, H., Stary, C., Vanderheiden, G., Weber, G., Ziegler, J. (1998a), “Towards an Information Society for All: An International R&D Agenda”, *International Journal of Human-Computer Interaction*, vol. 10(2), pp. 107-134.

Stephanidis, C., and Emiliani, P. L., (1999), ‘‘Connecting to the Information Society: A European Perspective’’, *Technology and Disability Journal*, 10, No. 1, 21–44.

Stephanidis, C. (ed.) (2001), “User Interfaces for All – Concepts, Methods and Tools”, Mahwah, NJ: Lawrence Erlbaum Associates.

Stephanidis, C., Paramythis, A., Sfyrakis, M., Savidis, A. (2001), “A Case Study in Unified User Interface Development: The AVANTI Web Browser”, in Stephanidis, C. (ed.), “User Interfaces for All”, Lawrence Erlbaum, ISBN 0-8058-2967-9.

Streitz, N.; Magerkurth, C.; Prante, T. & Rocker, C. (2005), “From information design to experience design: smart artefacts and the disappearing computer”, *Interactions* **12**(4), 21-25.

Strickland, D., Marcus, L., Mesibov, G.B., & Hogan, K. (1996), “Brief report: Two case studies using virtual reality as a learning tool for autistic children”, *Journal of Autism and Developmental Disorders*, 26(6), 651-660.

Takahashi, K., (2005), “Remarks on emotion recognition from bio-potential signals”, 2nd Int. Conf. “Autonomous Robots and Agents”, Palmerston North, New Zealand.

TC 173/SC2 - ISO 9999 (2007), “Assistive products for persons with disability -- Classification and terminology”, International Organization of Standardization, December 2007.

Tekin, S., Fairbanks, L. A., O'Connor, S., Rosenberg, S., Cummings, J.L. (2001), “Activities of Daily Living in Alzheimer's Disease”, *American Journal of Geriatric Psychiatry*, 9, 81 – 86.

Topo, P., Jylhä, M., Laine J. (2002), “Can the telephone using abilities of people with dementia be promoted? An evaluation of simple-to-use telephone”, *Technology and Disability* 14(2002) 3-13. IOS Press.

Tronnier, H., (2003), “CENELEC Work Shop – Smart House”, Final report, Euronorm, Kronberg.

Vanderheiden, G.C. (1990), ‘‘Thirty-Something (Million): Should They Be Exceptions?’’, *Human Factors* 32, No. 4, 383–396.

Vanderheiden, G.C. (1998), “Universal Design and Assistive Technology in Communication and Information Technologies: Alternatives or Complements?”, *Assistive Technology*, Vol. 10.1, pp. 29-36.

Vanderheiden, G. (1998b), “Assistive techniques & devices for persons with cognitive and language impairments”, Trace Research and Development Centre: Accessible Design, University of Wisconsin.

Wang, J., Yan, N., Liu, H., Liu, M., and Tai, C. (2007), "Brain-Computer Interfaces Based on Attention and Complex Mental Tasks", V.G. Duffy (Ed.) "Digital Human Modeling", HCII 2007, LNCS 4561, pp. 467–473. Springer-Verlag Berlin Heidelberg.

Wheeler, K., Jorgensen, C., (2003), "Gestures as Input: Neuroelectric Joysticks and Keyboards", *IEEE Pervasive Computing*, 2(2), 56-61.

Willems, CH., (2003), "Verkenning naar de informatiebehoefte bij de toepassing van domotica in de realisatie van woningen voor mensen met specifieke wensen", IRv Kenniscentrum voor revalidatie en handicap, Hoensbroek.

Xerox Innovation Group (2005), "Exploring the Unknown Leading to the Future", Xerox Corporation.

Yao, J., Schmitz, R., and Warren, S. (2005), "A wearable point-of-care system for home use that incorporates plug-and-play and wireless standards", *IEEE Transactions on Information Technology in Biomedicine*, vol. 9, no. 3, pp. 363-371, Sept. 2005.

Zimmermann, G., Vanderheiden, G., Ma, M., Gandy, M., Trewin, S., Laskowski, S. & Walker, M. (2004), "Universal remote console standard: toward natural user interaction in ambient intelligence", *in* 'CHI '04: CHI '04 extended abstracts on Human factors in computing systems', ACM Press, New York, NY, USA, pp. 1608--1609.

Appendix A – Annotated ISTAG scenarios

AmI enables people to configure and store their requirements according to their specific disability for various day life situations such as self-care activities, transportations, domestic duties, employment, communication, leisure activities and social participation in general. They have registered into the system all their requirements and preferences for every situation. The information is stored in separate profiles which can be easily activated through brief voice commands or via text/keyboard insertions.

In the scenarios, it assumed that people wear their P-com devices, which give them access to their personal area networks (PAN) allowing seamless and intuitive contacts. The individual P-com configurations, in comparison to standard P-com set up, activate alternative accessibility features necessary for individual interaction and control. Interaction can be based on voice commands and sounds, as well as, e.g., text, or force-feedback and motion-tracking mechanisms. Such features can be used as main preferences by any individual, as an alternative interaction technique, in situations where constant vision control on the P-com is not possible (for example while driving).

It is interesting to observe that the P-com must not be a highly sophisticated equipment, whose performances are limited by size, weight, and power. The intelligence necessary to support the complex transductions of information necessary to address the different modalities can be in the environment and in the network. The same is true for the complex interaction peripherals. In principle, the only limited factor can be its bandwidth.

It is assumed that elderly and disabled citizens are already well integrated in the Information Society, and the majority of participation barriers related to environmental factors has been potentially eliminated through the appropriate use of advanced ICT products.

Scenarios for people who are not able to see

<table>
<tr><th>Original scenario (Maria)</th><th>Problems</th><th>Possible solutions</th><th>AmI opportunities</th></tr>
<tr><td colspan="4">The environment is assumed to be totally unknown to Maria.

Being a blind person, Maria has a foldable tactile presentation system. Even if tactile presentations are in principle available for all users, she prefers to carry her own device so as to avoid potential problems during her trip.</td></tr>
<tr><td colspan="3">After a tiring long haul flight Maria passes through the arrivals hall of an airport in a Far Eastern country. She is travelling light, hand baggage only. When she comes to this particular country she knows that she can travel much lighter than a decade ago, when she had to carry a collection of different so-called personal computing devices (laptop PC, mobile phone, electronic organisers and sometimes beamers and printers). Her computing system for this trip is reduced to one highly personalised communications device, her ‘P–Com’ that she wears on her wrist.</td><td>Maria’s P-com can be equipped with specialised interfaces (e.g. a foldable tactile interface). When necessary the P-com can communicate with sophisticated peripherals (e.g. a tactile 3-D system) available in the environment.</td></tr>
<tr><td colspan="3">Maria calls the P-Com her ‘key of keys’ because it almost invisibly unlocks the doors she meets on her trip. It allows her to move around in an ambience that is shaped according to her needs and preferences. In the past travelling involved many different and complicated transactions with all sorts of different service vendors, often with gaps and incompatibilities between the different services. In the past few years, a series of multi-service vendors (MSVs) have emerged offering complete packages of services linked to the P-Com that tailor the user’s environment according to their preferences. User preferences are set up during an ‘initiation period’ during which personal agents (personal-servants or perservs) are instructed or learn how to obey their master’s wishes. These agents are in continual negotiation with those of participating service providers (such as shops, rental companies, hotels and so on).</td><td>This new situation, of interest for all people, can be particularly interesting for blind people, who may presently have problems in accessing complex information services.</td></tr>
<tr><td>A particular feature of this trip is that the country that Maria is visiting has since the previous year embarked on an ambitious ambient intelligence infrastructure programme. Thus</td><td>Navigating the environment.</td><td>The P-Com in communication with AmI guides Maria through the airport (e.g. by voice, or using haptic cues).</td><td>Navigation in the environment is considered as a problem for a blind person. Instead of creating new obstacles AmI has the potentiality of offering a solution to the mobility of blind people in</td></tr>
</table>

her visa for the trip was self-arranged and she is able to stroll through immigration without stopping because her P-Com is dealing with the ID checks as she walks.		This requires: • The knowledge of her position in the airport (granted by AmI); • The possibility of controlling the presence of unpredictable obstacles (people, baggage, etc.). The second problem can be solved with two approaches: • The first is based on the features of the AmI itself, which could contain a control system able to monitor tagged objects in real time and communicate with the P-com of passengers; • The second is based on a personal system (artificial virtual guide dog), that is a set of sensors (e.g. a worn T.V. camera, or some type of ultrasound or laser) able to spot possible obstacles. RFID on objects can be used for signalling the presence of obstacles to the virtual guide dog.	all environments where its facilities are deployed. Tracking people and offering context related information is supposed to be one of the standard features of AmI.
A rented car has been reserved for her and is waiting in an earmarked bay. The car opens as she approaches. It starts at the press of a button: she doesn't need a key. She still has to drive the car but she is supported in her journey downtown to the conference centre-hotel by the	Maria cannot drive	She uses a taxi. a) Her P-Com can guide her to the taxi rank or b) The taxi driver was informed from Maria's arrival beforehand and he picks her up at the door of the arrival lounge.	See previous point

traffic guidance system that had been launched by the city government as part of the 'AmI-Nation' initiative two years earlier.		The taxi driver's and Maria's P-Coms can communicate so that the driver can locate Maria.	
Downtown traffic has been a legendary nightmare in this city for many years, and draconian steps were taken to limit access to the city. But Maria has priority access rights into the central cordon because she has a reservation in the car park of the hotel. Central access however comes at a premium price, in Maria's case it is embedded in a deal negotiated between her personal agent and the transaction agents of the car-rental and hotel chains. Her firm operates centralised billing for these expenses and uses its purchasing power to gain access at attractive rates. Such preferential treatment for affluent foreigners was highly contentious at the time of the introduction of the route pricing system and the government was forced to hypothecate funds from the tolling system to the public transport infrastructure in return.			
In the car Maria's teenage daughter comes through on the audio system. Amanda has detected from 'En Casa' system at home that her mother is in a place that supports direct voice contact. However, even with all the route guidance support Maria wants to concentrate on her driving and says that she will call back from the hotel		.	Maria has the advantage of being able to speak immediately with her daughter.
Maria is directed to a parking slot in the underground garage of the newly constructed building of the Smar-tel Chain. She is met in the garage by the porter – the first contact with a real human in our story so far! He helps her with her luggage to her room.			
Her room adopts her 'personality' as she enters. The room temperature, default lighting and a range of video and music choices are displayed on	The traditional remote control is not accessible.	Maria can use the P-Com. Alternatively, AmI can describe to her the layout and the functionalities of the remote control.	AmI knows itself and its components. If necessary, it is able to describe the layout and the functionalities of the remote control and of the entire room.

the video wall. She needs to make some changes to her presentation – a sales pitch that will be used as the basis for a negotiation later in the day. Using voice commands she adjusts the light levels and commands a bath.	Maria cannot do two acoustic activities simultaneously	The actions must be sequenced, or an alternative interfaces (Braille) addressing a different modality may be used.	AmI is able to organize sequentially the flow of information and the performance of the necessary tasks, allocating the necessary time.
Then she calls up her daughter on the video wall, while talking she uses a traditional remote control system to browse through a set of webcast local news bulletins from back home that her daughter tells her about. They watch them together			The possibility of watching the news together and being able to comment them adds a very important social dimension to the interaction.
Later on she 'localises' her presentation with the help of an agent that is specialised in advising on local preferences (colour schemes, the use of language). She stores the presentation on the secure server at headquarters back in Europe. In the hotel's seminar room where the sales pitch is to take place, she will be able to call down an encrypted version of the	Maria cannot see her presentation (neither the colour scheme).	The agent that advises on preferred colour schemes should be reliable enough to detect and correct eventual contrast and related problems. Alternatively, a connection with the office is established through the broadband network, in order to allow a visual inspection of the results. If Maria was not born blind and knows colours, she can be informed vocally of the colour scheme.	The additional opportunities offered by AmI are related to the availability of broadband communication facilities. Mary can be helped by colleagues, who can work cooperatively across the network. In many situations human support can be more effective and acceptable than technological support.

presentation and give it a post presentation decrypt life of 1.5 minutes.			
The hotel offers neutral third part hosting of presentations but Maria wants to be sure for her own peace of mind that some of the sensitive material in the presentation will not sit around on a 3rd party server for prying eyes to see. To do this work, Maria is using hardware provided by the hotel, but with security clearance and access to her personal home workspace guaranteed by her P-Com.			Security is built in the system.
She goes downstairs to make her presentation…this for her is a high stress event. Not only is she performing alone for the first time, the clients concerned are well known to be tough players. Still, she doesn't actually have to close the deal this time. As she enters the meeting she raises communications access thresholds to block out anything but red-level 'emergency' messages.	Maria needs to know who is in the room.	The P-Coms communicate and exchange the information on who is attending the meeting.	Probably a normal handshake could be as much efficient and more pleasant.
	Maria needs to know when she can start her presentation	She gets a multi-modal confirmation (voice through earphone plus vibrator) that the presentation is ready for display.	
	Maria needs to control the pace of the presentation.	There is a tactile display in the room or she can use the personal tactile display. The tactile display has a copy of the presentation plus additional control functions (active functions), pointing facilities and slide content details.	In AmI the wide availability of tactile displays is part of the built in virtual reality interfaces.
The meeting is rough, but she feels it was a success. Coming out of the meeting she lowers the communication barriers again and picks up a number of amber level communications including one from her cardio-monitor warning her to take some rest now. The day has been long and stressing. She needs to chill out with a little meditation and medication. For Maria the meditation is a concert on the video wall and the medication….a large gin and tonic from her room's minibar.			

Original scenario (Dimitrios)	Problems	Possible solutions	AmI opportunities
It is four o'clock in the afternoon. Dimitrios, a 32 year-old person working in a food- multinational, is taking a coffee at his office's cafeteria, together with his boss and some colleagues. He doesn't want to be excessively bothered during this pause. Nevertheless, all the time he is receiving and dealing with incoming calls and mails. He is proud of 'being in communication with mankind': as are many of his friends and some colleagues. Dimitrios is wearing, embedded in his clothes, a 'gateway' or digital avatar of himself, familiarly known as 'Digital Me' or 'D-Me'. A D-Me is both a learning device, learning about Dimitrios from his interactions with his environment, and an acting device offering communication, processing and decision-making functionality. Dimitrios has partly 'programmed' the D-Me himself, at a very initial stage: it was, he says, a great personal experience to formalise somehow his identity and the way he envisaged his relations. At the time, he thought he would 'upgrade' this initial data periodically. But he didn't. He feels quite confident with his D-Me and relies upon its 'intelligent PDA-like' reactions.			Even if blind people do not normally have problems in interpersonal communication help in processing of the complex flow of communications and decision making can be very interesting.
Dimitrios has a '3P/3CAG D-Me'-it allows him to specify three privacy levels (3P) for personal data matched to three separate 'closed access group' (3CAG) memberships.			Privacy is a built in facility of AmI.
At 4:10 p.m. following other calls of secondary importance - answered formally in a smoothly multilingual reproduction of Dimitrio's voice and typical accent, a call from his wife is further analysed by his D-Me. The D-Me confronts available data registered from Dimitrios' environment (voices, themes, location, other 'patched' objects) to match the situation with this private call (Dimitrios' wife's voice, theme, emotional level). In a first attempt, Dimitrios' 'avatar-like' voice runs a brief conversation with Dimitrios' wife, with the intention of negotiating a delay while explaining his current situation. Simultaneously, Dimitrios' D-Me has caught a message from an older person's D-Me, located in the nearby metro station. This senior has left his home without his medicine and would feel at ease knowing where and how to access similar drugs in an easy way. He has addressed his query in natural speech to his D-Me. Dimitrios happens to suffer from similar health problems and uses the same drugs. Dimitrios' D-Me processes the data available to offer information to the senior. It 'decides' neither to reveal Dimitrios' identity (privacy level), nor to offer Dimitrios' direct help (lack of availability), but to list the closest drug shops, alternative drugs and contacts to a self-help group and medical contacts nearby in case of emergency. This information is shared with the senior's D-Me, rather than with the senior himself, to avoid useless information overload.			
The D-Me is equipped with voice, pattern and patch recognition capacity. It has to identify places and people, but also to register enough data to record the relevant events of Dimitrios' life to process it in its DMe profile and offer it			Functions of pattern and patch recognition can have an important

to other DMe's.			impact on access to information by blind people.
Meanwhile his wife's call is now interpreted by his D-Me as sufficiently pressing to mobilise Dimitrios. It 'rings' him using a pre-arranged call tone. Dimitrios takes up the call with one of the available 'Displayphones' in the cafeteria. Since the diffusion of D-Me, fewer people run around with mobile terminals. Public and private spaces have display terminals and your D-Me can point at the closest….functioning one!	Possible problems in localising the displayphone.	The P-com can communicate with the displayphone and, in cooperation with AmI, helps navigation to it. Alternatively Dimitrios can wear a special P-com that allows him to communicate directly with his wife.	The selection of different telecommunication facilities is available.
Dimitrios' wife hates his D-Me. She suspects him living parallel lives and whatever the practical aspects, she definitely would prefer having himright away on the phone. It has been a source of conflict from the start.			
The 'emergency' is about their child's homework. While doing his homework their 9 year-old son is meant to offer some insights on everyday life in Egypt. In a brief 3-way telephone conference, Dimitrios offers to pass over the query to the D-Me to search for an available direct contact with a child in Egypt. Ten minutes later, his son is videoconferencing at home with a girl of his own age, and recording this real-time translated conversation as part of his homework. All communicating facilities have been managed by Dimitrios' D-Me, even while it is still registering new data and managing other queries. The Egyptian correspondent is the daughter of a local businessman, well off and quite keen on technologies. Some luck (and income…) had to participate in what might become a longer lasting new relation.			For a blind person, normally communicating by voice an automatic translated conversation could be particularly useful.
Managing a service while choosing the best telecommunication means for the videoconference forms part of the role of the D-Me.			

Original scenario (Carmen	Problems	Possible solutions	AmI opportunities
The driver is part of a carpooling scheme of the transport management systems in the urban area where Carmen lives. Advanced payment and transactions systems are in place, which are able to calculate the amount of money that goes to the driver and the amount that goes to the transport operators.			
It is a normal weekday morning. Carmen wakes and plans her travel for the day. She wants to leave for work in half an hour and asks AmI, by means of a voice command, to find a vehicle to share with somebody on her route to work. AmI starts searching the trip database and, after checking the willingness of the driver, finds someone that will pass by in 40 minutes. The in-vehicle biosensor has recognised that this driver is a non-smoker –one of Carmen requirements for trip sharing. From that moment on, Carmen and her driver are in permanent contact if wanted (e.g. to allow the driver to alert Carmen if he/she will be late). Both wear their personal area networks (PAN) allowing seamless and intuitive contacts	Need of special Arrangements for travelling and meeting.	For the trip sharing, the Carmen's Aml informs the driver of her profile's data related to her disability, the destination and time details of the desire route, the way that he or she will recognise her at a meeting point, and the parameters for establishing (PAN) connection from the moment that they will agree. The driver is notified of Carmen's disability as this may have certain implications, for example in arranging the meeting point.	AmI knows the abilities/disabilities of Carmen and, if authorised by her, can use this information for helping in arranging her travelling to work.
Objects can be tracked through radio-frequency identification tags. These e-tags are very small, maximum of the size of a grain of rice and can be embedded in everyday objects. Everyone carrying a device equipped with a reader could access additional information and services relating to the tagged item.			Tags can be very useful for blind people. They can offer information to the blind persons or can be interrogated by them.
While taking her breakfast coffee	Need of alternative communication	Carmen's P-com in communication	The wide availability of speech

Carmen lists her shopping since she will have guests for dinner tonight. She would like also to cook a cake and the e-fridge flashes the recipe. It highlights the ingredients that are missing: milk and eggs. She completes the shopping on the e-fridge screen and asks for it to be delivered to the closest distribution point in her neighbourhood. This can be a shop, the postal office or a franchised nodal point for the neighbourhood where Carmen lives. All goods are smart tagged, so that Carmen can check the progress of her virtual shopping expedition, from any enabled device at home, the office or from a kiosk in the street. All goods are smart tagged, so that Carmen can check the progress of her virtual shopping expedition, from any enabled device at home, the office or from a kiosk in the street. She can be informed during the day on her shopping, agree with what has been found, ask for alternatives, where they are and when they will be delivered.	with the environment	with her e-fridge voices the recipe. The system concludes by listing the missing ingredients. Carmen completes the shopping list through brief voice commands. When Carmen is connected to the shop, all the information stored in tags is translated in a properly encoded format for her to receive. Carmen may choose to hear or read (e.g., in Braille) brief descriptions of the goods, or to have a full presentation of a particular product or store shelf. Presentations may contain information for the product characteristics (size, colour, and weight), the packing, the price, potential offers or alternative selections and other information that will help her to make her choice. Carmen's P-workstation enables her to explore and manipulate 3D models and artefacts by means of tactile interaction.	interfaces is very important for blind people. Tags in connection with telecommunication networks can help in exploring the local and remote environment. Tactile displays are supposed to be widely available.
In this scenario the environmental management system is not only connected to sensors that control vehicle engines or the police, which in case of accidents can transfer information to the traffic control network to re-route traffic. The system is also able to alert individuals with allergies to certain types of pollutants when a dangerous threshold is reached. Individuals will be informed of the unhealthy atmosphere and can decide whether to go out or stay home.			

Forty minutes later Carmen goes downstairs onto the street, as her driver arrives. When Carmen gets into the car, the VAN system (Vehicle Area Network) registers her and by doing that she sanctions the payment systems to start counting.	Difficulties in reaching the meeting point (navigation)	A sound notification from Aml informs Carmen that she should leave her flat, as her driver is arriving. While moving towards the meeting point, her "e-guide dog" (see Maria scenario), plugged-in to the P-com, informs her about any non-familiar physical obstacles that are on her way as her neighbours are moving out and the corridor is full of obstacles such as furniture and boxes. Carmen's "e-dog" voices proper directional instructions and guides her safely to the meeting point arranged with the driver.	AmI offers new and efficient support for navigating the environment, relying on information available in AmI and in personal support systems (e-guide dog).
A micro-payment system will automatically transfer the amount into the e-purse of the driver when she gets out of the car.			
In the car, the dynamic route guidance system warned the driver of long traffic jams up ahead due to an accident. The system dynamically calculates alternatives together with trip times. One suggestion is to leave the car at a nearby 'park and ride' metro stop. Carmen and her driver park the car and continue the journey by metro. On leaving the car Carmen's payment is deducted according to duration and distance.	Possible navigation problems.	The UAN (Underground Network Area) registers Carmen as a blind client and suggests routes and paths that are not too busy at that point, so she could manage to be at work on time. Her "e-guide dog" is waiting for her to decide about the way they will follow. A sound alert from the e-dog indicates that time is passing, so she has to quickly decide the direction to take.	AmI can support the mobility of Carmen in the city and give her context relevant information. The "e-guide dog", integrated in AmI, increases her autonomy in the environment.
Out of the metro station and whilst walking the minutes to her job, Carmen is alerted by her PAN that a Chardonnay wine that she has previously identified as a preferred choice is on promotion that day. She decides to add it to her shopping list and uses the opportunity to tell her wearable when she plans to leave work and where she wants to go. Carmen arrives at her job on time.			

On the way home the shared car system senses a bike on a dedicated lane approaching an intersection on their route. The driver is alerted and the system anyway gives preference to bikes, so a potential accident is avoided.			The system adds security to a blind person walking through the city.
A persistent high pressure for the last ten days has given fine weather but rising atmospheric pollutants. It is rush hour and the traffic density has caused pollution levels to rise above a control threshold. The city-wide engine control systems automatically lower the maximum speeds (for all motorised vehicles) and when the car enters a specific urban ring toll will be deducted via the Automatic Debiting System (ADS).			
Carmen arrives at the local distribution node (actually her neighbourhood corner shop) where she picks-up her goods. The shop has already closed. But the goods await Carmen in a smart delivery box. By getting them out, the system registers payment, and deletes the items from her shopping list. The list is complete. At home, her smart fridge screen will be blank.	Possible problems in accessing the smart delivery box.	The distribution point offers tactile accessibility features for the blind. However, Carmen prefers to interact with the delivery system through her P-com.	
Coming home, AmI welcomes Carmen and suggests to telework the next day: a big demonstration is announced downtown.			

Original scenario (Annette and Solomon)	Problems	Possible solutions	AmI opportunities
It is the plenary meeting of an environmental studies group in a local 'Ambient for Social Learning'. The group ranges from 10 to 75 years old. They share a common desire to understand the environment and environmental management. It is led by a mentor whose role it is to guide and facilitate the group's operation, but who is not necessarily very knowledgeable about environmental management. The plenary takes place in a room looking much like a hotel foyer with comfortable furniture pleasantly arranged. The meeting is open from 7.00-23.00 hours. Most participants are there for 4-6 hours. A large group arrives around 9.30 a.m. Some are scheduled to work together in real time and space and thus were requested to be present together (the ambient accesses their agendas to do the scheduling).			
A member is arriving: as she enters the room and finds herself a place to work, she hears a familiar voice asking "Hello Annette, I got the assignment you did last night from home: are you satisfied with the results?" Annette answers that she was happy with her strategy for managing forests provided that she had got the climatic model right: she was less sure of this.	Navigation in the environment.	Simplified version of Maria navigation scenario (the room is simpler than the airport).	AmI knows the individuals in the learning environment and can adapt itself to their needs.
Annette is an active and advanced student so the ambient says it might be useful if Annette spends some time today trying to pin down the problem with the model using enhanced interactive simulation and projection facilities. It then asks if Annette would give a brief presentation to the group. The ambient goes briefly through its understanding of Annette's availability and references for the	Problems with interactive simulation and projection facilities.	Nowadays, interactive simulation systems are inherently based on interaction paradigms using direct manipulation of objects and on complex (also three-dimensional) visual presentations. In this future environment the system will have evolved to be multimedia and multimodal. A possible solution for a blind person could be the evolution toward a virtual reality system based on sound and tactile interactions	The new technology developed for the implementation of the intelligent environment (e.g. tactile display technology, virtual reality, tactile input technology) is contribution toward an easier access to information by blind people.

<table>
<tr><td>day’s work. Finally, Annette agrees on her work programme for the day.</td><td></td><td>(tactile exploration of virtual objects both for input and output of data).</td><td></td></tr>
<tr><td colspan="4">One particularly long conversation takes place with Solomon who has just moved to the area and joined the group. The ambient establishes Solomon’s identity; asks Solomon for the name of an ambient that ‘knows’ Solomon; gets permission from Solomon to acquire information about Solomon’s background and experience in Environmental Studies. The ambient then suggests Solomon to join the meeting and to introduce himself to the group.</td></tr>
<tr><td colspan="4">In these private conversations the mental states of the group are synchronised with the ambient, individual and collective work plans are agreed and in most cases checked with the mentor through the ambient. In some cases the assistance of the mentor is requested. A scheduled plenary meeting begins with those who are present. Solomon introduces himself.</td></tr>
<tr><td rowspan="3">Annette gives a 3-D presentation of her assignment. A group member asks questions about one of Annette’s decisions and alternative visualisations are projected.</td><td>Annette needs to know who is in the environment.</td><td>The P-Coms communicate and exchange the information on who is attending the meeting.</td><td></td></tr>
<tr><td>Annette needs to know when she can start her presentation.</td><td>She gets a multi-modal confirmation (voice through earphone plus vibrator) that the presentation is ready for display.</td><td></td></tr>
<tr><td>Annette needs to control the pace of the presentation.</td><td>There is a tactile display in the room. The tactile display has a copy of the presentation plus additional control functions (active functions), pointing facilities and slide content details.</td><td>In AmI the wide availability of tactile displays is part of the built in virtual reality interfaces.</td></tr>
<tr><td colspan="4">During the presentation the mentor is feeding observations and questions to the ambient, together with William, an expert who was asked to join the meeting. William, although several thousand miles away, joins to make a comment and answer some questions. The session ends with a discussion of how Annette’s work contributes to that of the others and the proposal of schedules for the remainder of the day. The ambient suggests a schedule involving both shared and individual sessions.</td></tr>
<tr><td colspan="3">During the day individuals and sub-groups locate in appropriate spaces in the ambient to pursue appropriate learning experiences at a pace that suits them. The ambient negotiates its degree of participation in these experiences with the aid of the mentor. During the day the mentor and ambient converse frequently, establishing where the mentor might most usefully spend his time, and in some cases altering the schedule. The ambient and the mentor will spend some time negotiating shared experiences with other ambients – for example mounting a single musical concert with players from two or more distant sites. They will also deal with requests for references / profiles of individuals. Time</td><td>The knowledge of the user profiles and the availability of technologies addressing different modalities allows the structuring of the space(s) in a way that is suitable for the different users.</td></tr>
</table>

spent in the ambient ends by negotiating a homework assignment with each individual, but only after they have been informed about what the ambient expects to happen for the rest of the day and making appointments for next day or next time.	

Scenarios for people who have cognitive impairments

Cognitive resources are crucial capacities for successful and independent ageing. Cognition comprises human information processing functions and domains that allow us to access and maintain knowledge. Relevant domains are, for example, memory, language, orientation and problem solving. Impairments of cognitive functions such as recall and recognition (e.g., the ability to identify faces, objects and events), attention, learning and executive control processes interfere with daily functioning and severely degrade the quality of life. The prevalence of pathological cognitive changes increases with age. Its most prominent form, dementia, can render the affected subjects incapable of taking care of themselves. The most common form of dementia is Alzheimer's Disease (AD). Less severe forms of cognitive impairments are classified as age-associated memory impairment (AAMI) or mild cognitive impairment (MCI). Regardless of its severity, cognitive impairment results in diminution of social contact, leads to social exclusion, loneliness and depression.

In the scenarios reference is mainly made to people who have mild or moderate memory, language, orientation and problem solving problems that normally do not impede their independent living if suitably supported.

<table>
<tr><th>Original scenario (Maria)</th><th>Problems</th><th>Possible solutions</th><th>AmI opportunities</th></tr>
<tr><td colspan="4">Since it is not considered reasonable that an (older) person with cognitive disability can act as a “street warrior”, the scenario is worked out as an example of a person travelling in an unknown environment and checking in a hotel.

The environment is assumed to be totally unknown.</td></tr>
<tr><td colspan="3">After a tiring long haul flight Maria passes through the arrivals hall of an airport in a Far Eastern country. She is travelling light, hand baggage only. When she comes to this particular country she knows that she can travel much lighter than a decade ago, when she had to carry a collection of different so-called personal computing devices (laptop PC, mobile phone, electronic organisers and sometimes beamers and printers). Her computing system for this trip is reduced to one highly personalised communications device, her ‘P–Com’ that she wears on her wrist.</td><td>Even if it is not very likely that Maria needs to perform tasks for which the listed equipment are necessary, any simplification in the type and complexity of necessary devices can be particularly useful with this user group.</td></tr>
</table>

Maria calls the P-Com her 'key of keys' because it almost invisibly unlocks the doors she meets on her trip. It allows her to move around in an ambience that is shaped according to her needs and preferences. In the past travelling involved many different and complicated transactions with all sorts of different service vendors, often with gaps and incompatibilities between the different services. In the past few years, a series of multi-service vendors (MSVs) have emerged offering complete packages of services linked to the P-Com that tailor the user's environment according to their preferences. User preferences are set up during an 'initiation period' during which personal agents (personal-servants or perservs) are instructed or learn how to obey their master's wishes. These agents are in continual negotiation with those of participating service providers (such as shops, rental companies, hotels and so on).			The possibility of delegating to an agent the transactions needed for organising a trip abroad can be very important for an elderly person with cognitive limitations.
A particular feature of this trip is that the country that Maria is visiting has since the previous year embarked on an ambitious ambient intelligence infrastructure programme. Thus her visa for the trip was self-arranged and she is able to stroll through immigration without stopping because her P-Com is dealing with the ID checks as she walks.	Difficulties in navigating the environment may occur.	The P-Com in communication with AmI guides Maria through the airport (e.g. by voice). This requires knowledge of her position in the airport (granted by the AmI). The P-com also helps in instructing Maria about the sequence of necessary tasks.	The support in navigation by a equipment well known by the user is very important. The same approach can be used in all different environments, without need of learning new interaction styles and patterns of presentation of information. However, this is due not only to the use of an adapted equipment, but also to its integration with AmI.
A rented car has been reserved for her and is waiting in an earmarked bay. The car opens as she approaches. It starts at the press of a button: she doesn't need a key. She still has to drive the car but she is supported in her journey downtown to the conference centre-hotel by the traffic guidance system that had been launched by the city government as part of the 'AmI-Nation' initiative two years earlier.	Maria does not like to drive, particularly in an unknown environment.	She uses a taxi. a) Her P-Com can guide her to the taxi rank or b) the taxi driver was informed from Maria's arrival beforehand and he picks her up at the door of the arrival lounge. The taxi driver's P-Com and Maria's	The integration of the AmI support with the help by a person in continuous communication can be very useful. It can also concur to reduce stress in an unknown environment. It must also be considered (see Demetrios scenario) that real-time translation from one language to another is given for granted in AmI.

		can communicate, so that the driver can locate Maria.	
Downtown traffic has been a legendary nightmare in this city for many years, and draconian steps were taken to limit access to the city. But Maria has priority access rights into the central cordon because she has a reservation in the car park of the hotel. Central access however comes at a premium price, in Maria's case it is embedded in a deal negotiated between her personal agent and the transaction agents of the car-rental and hotel chains. Such preferential treatment for affluent foreigners was highly contentious at the time of the introduction of the route pricing system and the government was forced to hypothecate funds from the tolling system to the public transport infrastructure in return.			
In the car Maria's teenage daughter comes through on the audio system. Amanda has detected from 'En Casa' system at home that her mother is in a place that supports direct voice contact. However, even with all the route guidance support Maria wants to concentrate on her driving and says that she will call back from the hotel			In this case Maria is able to speak immediately with her daughter. The fact that the daughter knows that the mother is in a place where it can be contacted shows that remote "control" is part of the environment. This could be very important for Maria and her relatives.
Maria is directed to a parking slot in the underground garage of the newly constructed building of the Smar-tel Chain. She is met in the garage by the porter – the first contact with a real human in our story so far! He helps her with her luggage to her room.			
Her room adopts her 'personality' as she enters. The room temperature, default lighting and a range of video and music choices are displayed on the video wall. She needs to make some changes to her presentation – a sales pitch that will be used as the basis for a negotiation later in the day. Using voice commands she adjusts the light levels and commands a bath.	Maria may have difficulties with new environments	A description is given of the room and its facilities. The number and complexity of facilities to be made available can be chosen according Maria's profile. If necessary, the room can make all choices automatically.	AmI can continuously control Maria's behaviour according to her known habits and intervene if necessary, for example reminding tasks and helping in performing them. When necessary, AmI can contact the family or a carer for advice and help.
	The remote control for making choices may be too complex to be used	Maria can use the P-Com, whose remote control functions are simplified according to her characteristics and preferences. The P-com guides Maria through the	

		possible choices.	
	Maria cannot perform different activities simultaneously	The actions must be sequenced.	
Then she calls up her daughter on the video wall, while talking she uses a traditional remote control system to browse through a set of webcast local news bulletins from back home that her daughter tells her about. They watch them together.			The contact with the family in a relaxed environment can be important for Maria to reduce stress and for the family to monitor her situation without a too intrusive control.
The day has been long and stressing. She needs to chill out with a little meditation and medication. For Maria the meditation is a concert on the video wall and the medication….a large gin and tonic from her room's minibar.			

Original scenario (Dimitrios)	Problems	Possible solutions	AmI opportunities
It is four o'clock in the afternoon. Dimitrios, a 32 year-old cognitively disabled person working in a food- multinational, is taking a coffee at his office's cafeteria, together with his boss and some colleagues. He doesn't want to be excessively bothered during this pause. Nevertheless, all the time he is receiving and dealing with incoming calls and mails.			
He is proud of 'being in communication with mankind': as are many of his friends and some colleagues. Dimitrios is wearing, embedded in his clothes, a 'gateway' or digital avatar of himself, familiarly known as 'Digital Me' or 'D-Me'. A D-Me is both a learning device, learning about Dimitrios from his interactions with his environment, and an acting device offering communication, processing and decision-making functionality. Dimitrios has partly 'programmed' the D-Me himself, at a very initial stage: it was, he says, a great personal experience to formalise somehow his identity and the way he envisaged his relations. At the time, he thought he would 'upgrade' this initial data periodically. But he didn't. He feels quite confident with his D-Me and relies upon its 'intelligent PDA-like' reactions.			Being continuously in contact can be very useful for Demetrios. His D-Me can cover some of his problems with memory and problem solving. Automatic learning can help in long term adaptation to Demetrios' behaviour and the short term fluctuations of his capabilities. When necessary D-Me can be part of a control system, in continuous contact with relatives or helpers.
Dimitrios has a '3P/3CAG D-Me'-it allows him to specify three privacy levels (3P) for personal data matched to three separate 'closed access group' (3CAG) memberships.			Privacy control is a standard feature of AmI.
At 4:10 p.m. following other calls of secondary importance - answered formally in a smoothly multilingual reproduction of Dimitrio's voice and typical accent, a call from his wife is further analysed by his D-Me. The D-Me confronts available data registered from Dimitrios' environment (voices, themes, location, other 'patched' objects) to match the situation with this private call (Dimitrios' wife's voice, theme, emotional level). In a first attempt, Dimitrios' 'avatar-like' voice runs a brief conversation with Dimitrios' wife, with the intention of negotiating a delay while explaining his current situation			Given the peculiar Dimitrios' situation, it would probably be suitable to grant some selected people a direct connection with him.
Simultaneously, Dimitrios' D-Me has caught a message from an older person's D-Me, located in the nearby metro station. This senior has left his home without his medicine and would feel at ease knowing where and how to access similar drugs in an easy way. He has addressed his query in natural speech to his D-Me. Dimitrios happens to suffer from similar health problems and uses the same drugs. Dimitrios' D-Me processes the data available to offer information to the senior. It 'decides' neither to reveal Dimitrios' identity (privacy level), nor to offer Dimitrios' direct help (lack of availability), but to list the closest drug shops, alternative drugs and contacts to a self-help group and medical contacts nearby in case of emergency. This information is shared with the senior's D-Me, rather than with the senior himself, to avoid useless information overload.			
The D-Me is equipped with voice, pattern and patch recognition capacity. It has to identify places and people, but also to			This can give D-Me the capability of

<table>
<tr><td colspan="3">register enough data to record the relevant events of Dimitrios' life to process it in its DMe profile and offer it to other DMe's.</td><td>recognising people and objects, helping Demetrios when he has problems in recognising people and remembering complex functions of objects.</td></tr>
<tr><td>Meanwhile his wife's call is now interpreted by his D-Me as sufficiently pressing to mobilise Dimitrios. It 'rings' him using a pre-arranged call tone. Dimitrios takes up the call with one of the available 'Displayphones' in the cafeteria. Since the diffusion of D-Me, fewer people run around with mobile terminals. Public and private spaces have display terminals and your D-Me can point at the closest….functioning one!</td><td>Problems in localising and using the displayphone.</td><td>The P-com can communicate with the displayphone and, in cooperation with the AI, help navigation to it.

The displayphone adapts itself to the preferences (media, complexity) of the system that Dimitrios is using at home. Support is automatically given if necessary.

Alternatively, Dimitrios may be given the possibility of using his personal P-com.</td><td>The complexity of the displayphone (functions, tasks to be carried out to use it, etc.) can be matched to Demetrios' capabilities.

The system can be set up to mimic the functionalities and interface of a system he is normally using.</td></tr>
<tr><td colspan="4">Dimitrios' wife hates his D-Me. She suspects him living parallel lives and whatever the practical aspects, she definitely would prefer having him right away on the phone. It has been a source of conflict from the start.</td></tr>
<tr><td colspan="3">The 'emergency' is about their child's homework. While doing his homework their 9 year-old son is meant to offer some insights on everyday life in Egypt. In a brief 3-way telephone conference, Dimitrios offers to pass over the query to the D-Me to search for an available direct contact with a child in Egypt. Ten minutes later, his son is videoconferencing at home with a girl of his own age, and recording this real-time translated conversation as part of his homework. All communicating facilities have been managed by Dimitrios' D-Me, even while it is still registering new data and managing other queries. The Egyptian correspondent is the daughter of a local businessman, well off and quite keen on technologies. Some luck (and income…) had to participate in what might become a longer lasting new relation.</td><td>In social contacts mediated by telecommunication D-me can try to cover possible Demetrios' problems, dealing with complex tasks and interactions and problem solving functions.</td></tr>
<tr><td colspan="4">Managing a service while choosing the best telecommunication means for the videoconference forms part of the role of the D-Me.</td></tr>
</table>

Original scenario (Carmen)	Problems	Possible solutions	AmI opportunities
The driver is part of a carpooling scheme of the transport management systems in the urban area where Carmen lives. Advanced payment and transactions systems are in place, which are able to calculate the amount of money that goes to the driver and the amount that goes to the transport operators.			
It is a normal weekday morning. Carmen wakes and plans her travel for the day. She wants to leave for visiting a friend in half an hour and asks AmI, by means of a voice command, to find a vehicle to share with somebody on her route. AmI starts searching the trip database and, after checking the willingness of the driver, finds someone that will pass by in 40 minutes. The in-vehicle biosensor has recognised that this driver is a non-smoker – one of Carmen requirements for trip sharing. From that moment on, Carmen and her driver are in permanent contact if wanted (e.g. to allow the driver to alert Carmen if he/she will be late). Both wear their personal area networks (PAN) allowing seamless and intuitive contacts	Need of special arrangements for travelling and meeting.	For the trip sharing, AmI informs the driver of Carmen's profile data related to her age and disability, the destination and time details of the desire route, the way that he or she will recognise her at a meeting point, and the parameters for establishing (PAN) connection from the moment that they will agree. The driver is notified of Carmen's age and disability as this may have certain implications, for example for the type of vehicle and in arranging the meeting point.	If necessary, all operations for travel planning can be carried out by one of Carmen's agents (see Maria and Demetrios scenarios). This can be useful not only to help Carmen when she is really uable to perform required tasks, but also to reduce stress.
Objects can be tracked through radio-frequency identification tags. These etags are very small, maximum of the size of a grain of rice and can be embedded in everyday objects. Everyone carrying a device equipped with a reader could access additional information and services relating to the tagged item.			etags, in cooperation with AmI, can be very useful to help memory functions.
While taking her breakfast coffee Carmen lists her shopping since she will have guests for dinner tonight.	Carmen needs guidance through the required actions	Carmen is reminded that she will have guests for dinner and suggested a selection of menus extracted from	The level of support by AmI can be matched to the severity of Carmen's problems.

She would like also to cook a cake and the e-fridge flashes the recipe. It highlights the ingredients that are missing: milk and eggs. She completes the shopping on the e-fridge screen and asks for it to be delivered to the closest distribution point in her neighbourhood. This can be a shop, the postal office or a franchised nodal point for the neighbourhood where Carmen lives. All goods are smart tagged, so that Carmen can check the progress of her virtual shopping expedition, from any enabled device at home, the office or from a kiosk in the street. All goods are smart tagged, so that Carmen can check the progress of her virtual shopping expedition, from any enabled device at home, the office or from a kiosk in the street. She can be informed during the day on her shopping, agree with what has been found, ask for alternatives, where they are and when they will be delivered.		her known preferences. After a choice is made the e-fridge lists the missing ingredients. Carmen completes the shopping list through brief voice commands. When Carmen is connected to the shop, all the information stored in tags is translated in a properly encoded format for her to receive.	In cases of mild cognitive problems, AmI can remind and suggest, as a friend in the house. In serious cases, AmI can completely control the situation: preparing a balanced diet for Carmen based on past habits, checking the availability of the food, ordering it, caring for delivery at home, and suggesting all the steps necessary for the preparation of food. This can be done autonomously or in cooperation with a relative or carer. Obviously the security part of AmI will take care of avoiding risks. The level of control by Carmen can be set at any possible/desired level.
In this scenario the environmental management system is not only connected to sensors that control vehicle engines or the police, which in case of accidents can transfer information to the traffic control network to re-route traffic. The system is also able to alert individuals with allergies to certain types of pollutants when a dangerous threshold is reached. Individuals will be informed of the unhealthy atmosphere and can decide whether to go out or stay home.			
Forty minutes later Carmen goes downstairs onto the street, as her driver arrives. When Carmen gets into the car, the VAN system	Possible problems of navigation to the meeting point.	Carmen is notified that she should leave her flat, as her driver is arriving. If necessary, while moving towards the meeting, her P-com can	If necessary, the P-com can notify the news that Carmen is leaving home to a control centre or to a relative. A continuous connection can then be

(Vehicle Area Network) registers her and by doing that she sanctions the payment systems to start counting.		remind her the route to follow.	established and Carmen can be tracked during her trip. AmI as usch can be used as a contro system.
A micro-payment system will automatically transfer the amount into the e-purse of the driver when she gets out of the car.			This type of services frees Carmen from financial transactions.
In the car, the dynamic route guidance system warned the driver of long traffic jams up ahead due to an accident. The system dynamically calculates alternatives together with trip times. One suggestion is to leave the car at a nearby 'park and ride' metro stop. Carmen and her driver park the car and continue the journey by metro. On leaving the car Carmen's payment is deducted according to duration and distance.	Possible problems in travelling alone and in navigation.	The UAN (Underground Network Area) registers Carmen as an older client. It connects with the control centre to verify whether Carmen may be allowed to travel alone with the metro or she must be assisted. If she can travel alone, the P-com takes care of guiding her through the space and advising her about the tasks necessary for arriving to the friend's house.	The level of support can be easily tuned to Carmen's capabilities (probably changing in time).
Out of the metro station and whilst walking the minutes to her job, Carmen is alerted by her PAN that a Chardonnay wine that she has previously identified as a preferred choice is on promotion that day. She decides to add it to her shopping list and uses the opportunity to tell her wearable when she plans to leave her friend and where she wants go. Carmen arrives at her friend's home on time.			
On the way home the shared car system senses a bike on a dedicated lane approaching an intersection on their route. The driver is alerted and the system anyway gives preference to bikes, so a potential accident is avoided.			This can be an invaluable help for Carmen when going around alone. If the system becomes aware of Carmen's problems, for example evident confusion in finding her way and problems with coping with the environment, it can connect with a

			relative or a control centre. The connection can be granted by Carmen's P-com without infringement of her privacy.
A persistent high pressure for the last ten days has given fine weather but rising atmospheric pollutants. It is rush hour and the traffic density has caused pollution levels to rise above a control threshold. The city-wide engine control systems automatically lower the maximum speeds (for all motorised vehicles) and when the car enters a specific urban ring toll will be deducted via the Automatic Debiting System (ADS).			
Carmen arrives at the local distribution node (actually her neighbourhood corner shop) where she picks-up her goods. The shop has already closed. But the goods await Carmen in a smart delivery box. By getting them out, the system registers payment, and deletes the items from her shopping list. The list is complete. At home, her smart fridge screen will be blank.	Possible problems in reminding to collect things and operate the system when unmanned.	Carmen is reminded that she must pick up her goods from the distribution point. The distribution point offers all the support to allow her to retrieve the goods even if the point is unmanned. The P-com guides her back home	
Coming home, AmI welcomes Carmen and suggests to stay at home the next day: a big demonstration is announced downtown.			

<table>
<tr><th>Original scenario (Annette and Solomon)</th><th>Problems</th><th>Possible solutions</th><th>AmI opportunities</th></tr>
<tr><td colspan="4">Some modifications are introduced in the scenario, taking into account that Annette may not necessarily be and advanced student, but only interested in having basic information about environmental topics.

Additionally, it must be considered that this new learning environment is characterised by its adaptability to individual interests, learning style and capabilities.</td></tr>
<tr><td colspan="3">It is the plenary meeting of an environmental studies group in a local 'Ambient for Social Learning'. The group ranges from 10 to 75 years old. They share a common desire to understand the environment and environmental management. It is led by a mentor whose role it is to guide and facilitate the group's operation, but who is not necessarily very knowledgeable about environmental management. The plenary takes place in a room looking much like a hotel foyer with comfortable furniture pleasantly arranged. The meeting is open from 7.00-23.00 hours. Most participants are there for 4-6 hours. A large group arrives around 9.30 a.m. Some are scheduled to work together in real time and space and thus were requested to be present together (the ambient accesses their agendas to do the scheduling).</td><td>The comfortable environment, the social contacts and the possibility of matching the education features (e.g. speed) to the individual are of paramount importance for this user group.</td></tr>
<tr><td>A member is arriving: as she enters the room and finds herself a place to work, she hears a familiar voice asking "Hello Annette, I got the assignment you did last night from home: are you satisfied with the results?" Annette answers that she was happy with the preliminary information she was able to find about forests but there are some aspects she would clarify.</td><td>Navigation to the place to work</td><td>AmI guides Annette through the room (e.g. by voice or visual messages). This requires the knowledge of her position in the room (granted by AmI).</td><td></td></tr>
<tr><td>Annette is an active student so the ambient says it might be useful if Annette spends some time today</td><td>Problems with interactive simulation and projection facilities.</td><td>The interactive simulation and projection facilities are enhanced not only from the perspective of</td><td>A continuous support is granted by AmI, that is able to adapt to the users (also to the moods of the users).</td></tr>
</table>

<table>
<tr><td>trying to clarify the aspects of interest taking also advantage of the enhanced interactive simulation and projection facilities. It then asks if Annette would give a brief presentation to the group. The ambient goes briefly through its understanding of Annette’s availability and references for the day’s work. Finally, Annette agrees on her work programme for the day.</td><td></td><td>technical performance (for example 3D presentations), but also for their capability of adaptation to the needs of the users, both guiding them through the tasks needed for presentation and tailoring performances to the complexity of the required presentation (this requires that the system is designed taking into account the needs of all potential users).</td><td></td></tr>
<tr><td colspan="4">One particularly long conversation takes place with Solomon who has just moved to the area and joined the group. The ambient establishes Solomon’s identity; asks Solomon for the name of an ambient that ‘knows’ Solomon; gets permission from Solomon to acquire information about Solomon’s background and experience in Environmental Studies. The ambient then suggests Solomon to join the meeting and to introduce himself to the group.</td></tr>
<tr><td colspan="3">In these private conversations the mental states of the group are synchronised with the ambient, individual and collective work plans are agreed and in most cases checked with the mentor through the ambient. In some cases the assistance of the mentor is requested. A scheduled plenary meeting begins with those who are present. Solomon introduces himself.</td><td>This socialization aspects are particularly important for this group of users.</td></tr>
<tr><td>Annette gives a 3-D presentation of her assignment. A group member asks questions about one of Annette’s decisions and alternative visualisations are projected.</td><td>Problems with presentation.</td><td>If Annette is willing to give a presentation, the same considerations as for the simulation and projection system apply.</td><td></td></tr>
<tr><td colspan="4">During the presentation the mentor is feeding observations and questions to the ambient, together with William, an expert who was asked to join the meeting. William, although several thousand miles away, joins to make a comment and answer some questions. The session ends with a discussion of how Annette’s work

contributes to that of the others and the proposal of schedules for the remainder of the day. The ambient suggests a schedule involving both shared and individual sessions.</td></tr>
<tr><td colspan="3">During the day individuals and sub-groups locate in appropriate spaces in the ambient to pursue appropriate learning experiences at a pace that suits them. The ambient negotiates its degree of participation in these experiences with the aid of the mentor. During the day the mentor and ambient converse frequently, establishing where the mentor might</td><td>One of the most interesting characteristics in this learning environment is its possibility of</td></tr>
</table>

most usefully spend his time, and in some cases altering the schedule. The ambient and the mentor will spend some time negotiating shared experiences with other ambients – for example mounting a single musical concert with players from two or more distant sites. They will also deal with requests for references / profiles of individuals. Time spent in the ambient ends by negotiating a homework assignment with each individual, but only after they have been informed about what the ambient expects to happen for the rest of the day and making appointments for next day or next time.	being tailored physically (organization of space and availability of multimedia support) and conceptually (type of learning material, speed of presentation) to individual users. Moreover there is a mix of social exchanges (with other learning people, the mentor and external experts), that can be of invaluable help for this user group. The mentor himself is not an expert in the topics to be learned but a mediator between different interests and needs. Care is not only given to the efficiency of learning but to the “mood” of individuals and groups.

Scenarios for people who cannot hear

The scenarios are commented from the perspective of a person who cannot hear. The person can or cannot be able to speak.

Original scenario (Maria)	Problems	Possible solutions	AmI opportunities
After a tiring long haul flight Maria passes through the arrivals hall of an airport in a Far Eastern country. She is travelling light, hand baggage only. When she comes to this particular country she knows that she can travel much lighter than a decade ago, when she had to carry a collection of different so-called personal computing devices (laptop PC, mobile phone, electronic organisers and sometimes beamers and printers). Her computing system for this trip is reduced to one highly personalised communications device, her 'P–Com' that she wears on her wrist.			The P-com can transmit text and can be used as a text telephone with all P-coms. It is equipped with a speech recognizer to transform speech into text and with a speech synthesiser to be used if Maria cannot speak. Translation from speech to sign language and vice versa can be built in the P-com or offered by AmI. Obviously, this requires that the different sign languages are taken into account when automatic translation systems are set up.
Maria calls the P-Com her 'key of keys' because it almost invisibly unlocks the doors she meets on her trip. It allows her to move around in an ambience that is shaped according to her needs and preferences. In the past travelling involved many different and complicated transactions with all sorts of different service vendors, often with gaps and incompatibilities between the different services. In the past few years a series of multi-service vendors (MSVs) have emerged offering complete packages of services linked to the P-Com that tailor the user's environment according to their preferences. User preferences are set up during an 'initiation period' during which personal agents (personal-servants or perservs) are instructed or learn how to obey their master's wishes. These agents are in continual negotiation with those of participating service providers (such as shops, rental companies, hotels and so on).			This can be useful for a deaf person, even if AmI is by default a very sophisticated relay system and therefore interpersonal communication with people who are not deaf is possible (see previous comment).

A particular feature of this trip is that the country that Maria is visiting has since the previous year embarked on an ambitious ambient intelligence infrastructure programme. Thus her visa for the trip was self-arranged and she is able to stroll through immigration without stopping because her P-Comm is dealing with the ID checks as she walks.	Navigating the environment.	It is given for granted that in the multimedia and multimodal AmI environment all navigation information is also available in a visual form. If necessary, the P-com can cooperate with AmI to display information only when necessary, e.g. on screens in the environment or a personal display (for example projection spectacles).	The adaptability of AmI to the capabilities of all people is a very important improvement in comparison to present situation.
A rented car has been reserved for her and is waiting in an earmarked bay. The car opens as she approaches. It starts at the press of a button: she doesn't need a key. She still has to drive the car but she is supported in her journey downtown to the conference centre-hotel by the traffic guidance system that had been launched by the city government as part of the 'AmI-Nation' initiative two years earlier.	Access to audio signal in the environment.	Sensors in the car can transform signals in the environment into visual signals.	
Downtown traffic has been a legendary nightmare in this city for many years, and draconian steps were taken to limit access to the city. But Maria has priority access rights into the central cordon because she has a reservation in the car park of the hotel. Central access however comes at a premium price, in Maria's case it is embedded in a deal negotiated between her personal agent and the transaction agents of the car-rental and hotel chains. Her firm operates centralised billing for these expenses and uses its purchasing power to gain access at attractive rates. Such preferential treatment for affluent foreigners was highly contentious at the time of the introduction of the route pricing system and the government was forced to hypothecate funds from the tolling system to the public transport infrastructure in return.			
In the car Maria's teenage daughter comes through on the audio system.	Possible problems in knowing that	The communication system takes care of advising the daughter that her mother is	The P-com has an interface matched

Amanda has detected from 'En Casa' system at home that her mother is in a place that supports direct voice contact. However, even with all the route guidance support Maria wants to concentrate on her driving and says that she will call back from the hotel	a call is arriving.	driving and therefore she may not be able to respond immediately. A visual signal makes Maria aware of the call (a green light means "family"). She can stop and answer. Otherwise, the P-com will give her detailed information of the call as soon as possible.	to the needs of the individual user.
Maria is directed to a parking slot in the underground garage of the newly constructed building of the Smar-tel Chain. She is met in the garage by the porter – the first contact with a real human in our story so far! He helps her with her luggage to her room.			
Her room adopts her 'personality' as she enters. The room temperature, default lighting and a range of video and music choices are displayed on the video wall. She needs to make some changes to her presentation – a sales pitch that will be used as the basis for a negotiation later in the day. Using voice commands she adjusts the light levels and commands a bath.	Access to the adio component of the video transmission.	Video can be automatically captioned.	Availability of advanced speech processing capabilities for automatic transduction from speech to text and text to speech.
Then she calls up her daughter on the video wall, while talking she uses a traditional remote control system to browse through a set of webcast local news bulletins from back home that her daughter tells her about.They watch them			Maria can read the news. Videos are automatically captioned. Conversation with the daughter is through AmI (relay service).

together			
Later on she 'localises' her presentation with the help of an agent that is specialised in advising on local preferences (colour schemes, the use of language). She stores the presentation on the secure server at headquarters back in Europe. In the hotel's seminar room where the sales pitch is take place, she will be able to call down an encrypted version of the presentation and give it a post presentation decrypt life of 1.5 minutes.			
The hotel offers neutral third part hosting of presentations but Maria wants to be sure for her own peace of mind that some of the sensitive material in the presentation will not sit around on a 3rd party server for prying eyes to see. To do this work, Maria is using hardware provided by the hotel, but with security clearance and access to her personal home workspace guaranteed by her P-Com.			
She goes downstairs to make her presentation…this for her is a high stress event. Not only is she performing alone for the first time, the clients concerned are well known to be tough players. Still, she doesn't actually have to close the deal this time. As she enters the meeting she raises communications access thresholds to block out anything but red-level 'emergency' messages.	Problems in the presentation	Output No problems in the presentation, if Maria is able to speak. Otherwise she can use a speech synthesizer (see Demetrios scenario). In the discussion she can type answers to be read or synthesised. The presentation can be controlled using a gesture recognition system. Input During the discussion a speech recognition system is used.	All these problems are solved due the development of technologies necessary for the implementation of AmI.
The meeting is rough, but she feels it was a success. Coming out of the meeting she lowers the communication barriers again and picks up a number of amber level communications including one from her cardio-monitor warning her to take some rest now. The day has been long and stressing. She needs to chill out with a little meditation and medication. For Maria the meditation is a movie on the video wall and the medication….a large gin and tonic from her room's minibar.			

<table>
<tr><th>Original scenario (Dimitrios)</th><th>Problems</th><th>Possible solutions</th><th>AmI opportunities</th></tr>
<tr><td colspan="3">It is four o'clock in the afternoon. Dimitrios, a 32 year person working in a food- multinational, is taking a coffee at his office's cafeteria, together with his boss and some colleagues. He doesn't want to be excessively bothered during this pause. Nevertheless, all the time he is receiving and dealing with incoming calls and mails.

He is proud of 'being in communication with mankind': as are many of his friends and some colleagues. Dimitrios is wearing, embedded in his clothes, a 'gateway' or digital avatar of himself, familiarly known as 'Digital Me' or 'D-Me'. A D-Me is both a learning device, learning about Dimitrios from his interactions with his environment, and an acting device offering communication, processing and decision-making functionality. Dimitrios has partly 'programmed' the D-Me himself, at a very initial stage: it was, he says, a great personal experience to formalise somehow his identity and the way he envisaged his relations. At the time, he thought he would 'upgrade' this initial data periodically. But he didn't. He feels quite confident with his D-Me and relies upon its 'intelligent PDA-like' reactions.</td><td>D-Me is able to carry out most of normal transactions without making other people aware of his limitations. Obviously a trade-off between efficiency and human contact must be taken care of, but in many situation Demetrios' agent controlled by his D-me can be very useful to solve a lot of practical problems.</td></tr>
<tr><td colspan="4">Dimitrios has a '3P/3CAG D-Me'-it allows him to specify three privacy levels (3P) for personal data matched to three separate 'closed access group' (3CAG) memberships.</td></tr>
<tr><td colspan="4">At 4:10 p.m. following other calls of secondary importance - answered formally in a smoothly multilingual reproduction of Dimitrio's voice and typical accent, a call from his wife is further analysed by his D-Me. The D-Me confronts available data registered from Dimitrios' environment (voices, themes, location, other 'patched' objects) to match the situation with this private call (Dimitrios' wife's voice, theme, emotional level). In a first attempt, Dimitrios' 'avatar-like' voice runs a brief conversation with Dimitrios' wife, with the intention of negotiating a delay while explaining his current situation.

Simultaneously, Dimitrios' D-Me has caught a message from an older person's D-Me, located in the nearby metro station. This senior has left his home without his medicine and would feel at ease knowing where and how to access similar drugs in an easy way. He has addressed his query in natural speech to his D-Me. Dimitrios happens to suffer from similar health problems and uses the same drugs. Dimitrios' D-Me processes the data available to offer information to the senior. It 'decides' neither to reveal Dimitrios' identity (privacy level), nor to offer Dimitrios' direct help (lack of availability), but to list the closest drug shops, alternative drugs and contacts to a self-help group and medical contacts nearby in case of emergency. This information is shared with the senior's D-Me, rather than with the senior himself, to avoid useless information overload.</td></tr>
<tr><td colspan="3">The D-Me is equipped with voice, pattern and patch recognition capacity. It has to identify places and people, but also to register enough data to record the relevant events of Dimitrios' life to process it in its DMe profile and offer it to</td><td>It is important to note that capabilities of the D-me can</td></tr>
</table>

other DMe's.			implement a complete relay centre, also able to deal with sign language.
Meanwhile his wife's call is now interpreted by his D-Me as sufficiently pressing to mobilise Dimitrios. It 'rings' him using a pre-arranged call tone. Dimitrios takes up the call with one of the available 'Displayphones' in the cafeteria. Since the diffusion of D-Me, fewer people run around with mobile terminals. Public and private spaces have display terminals and your D-Me can point at the closest….functioning one!	Possible problems in using the displayphone	Dimitrios is alerted by vibration with a specific frequency. For output (to Demetrios) the displayphone is able to display text messages. Alternatively, a speech recogniser or an animation software in the displayphone itself, or connected to the P-com, can take care of the output information (translating speech to text or speech to lip movements and/or sign language). For input (from Demetrios) the speech synthesizer of the P-com can be used, if Dimitrios is not able to speak. Input may be provided using text or sign language and/or lip reading recognition.	
Dimitrios' wife hates his D-Me. She suspects him living parallel lives and whatever the practical aspects, she definitely would prefer having him right away on the phone. It has been a source of conflict from the start.			
The 'emergency' is about their child's homework. While doing his homework their 9 year-old son is meant to offer some insights on everyday life in Egypt. In a brief 3-way telephone conference, Dimitrios offers to pass over the query to the D-Me to search for an available direct contact with a child in Egypt. Ten minutes later, his son is videoconferencing at home with a girl of his own age, and recording this real-time translated conversation as part of his homework. All communicating facilities have been managed by Dimitrios' D-Me, even while it is still registering new data and managing other queries. The Egyptian correspondent is the daughter of a local businessman, well off and quite keen on technologies. Some luck (and income…) had to participate in what might become a longer lasting new relation.			

<table>
<tr><th>Original scenario (Carmen)</th><th>Problems</th><th>Possible solutions</th><th>AmI opportunities</th></tr>
<tr><td colspan="4">The driver is part of a carpooling scheme of the transport management systems in the urban area where Carmen lives. Advanced payment and transactions systems are in place, which are able to calculate the amount of money that goes to the driver and the amount that goes to the transport operators.</td></tr>
<tr><td>It is a normal weekday morning. Carmen wakes and plans her travel for the day. She wants to leave for work in half an hour and asks AmI, by means of a voice command, to find a vehicle to share with somebody on her route to work. AmI starts searching the trip database and, after checking the willingness of the driver, finds someone that will pass by in 40 minutes. The in-vehicle biosensor has recognised that this driver is a non-smoker –one of Carmen requirements for trip sharing. From that moment on, Carmen and her driver are in permanent contact if wanted (e.g. to allow the driver to alert Carmen if he/she will be late). Both wear their personal area networks (PAN) allowing seamless and intuitive contacts</td><td>Need of special arrangements for travelling and meeting.</td><td>If Carmen is able to speak, she can use voice commands. Alternatively she can use a keyboard.

The driver may be notified that Carmen is deaf and asked to use text for communication. While he is driving and cannot type text messages, a speech recognition system in Carmen's communicator can be used.

Carmen can communicate with the driver using text transduced to speech for the driver.</td><td>A possible solution today would be the use of a relay service. As previously pointed out AmI can be considered a very sophisticated relay service.</td></tr>
<tr><td colspan="4">Objects can be tracked through radio-frequency identification tags. These e-tags are very small, maximum of the size of a grain of rice and can be embedded in everyday objects. Everyone carrying a device equipped with a reader could access additional information and services relating to the tagged item.</td></tr>
<tr><td colspan="4">While taking her breakfast coffee Carmen lists her shopping since she will have guests for dinner tonight. She would like also to cook a cake and the e-fridge flashes the recipe. It highlights the ingredients that are missing: milk and eggs. She completes the shopping on the e-fridge screen and asks for it to be delivered to the closest distribution point in her neighbourhood. This can be a shop, the postal office or a franchised nodal point for the neighbourhood where</td></tr>
</table>

Carmen lives. All goods are smart tagged, so that Carmen can check the progress of her virtual shopping expedition, from any enabled device at home, the office or from a kiosk in the street. She can be informed during the day on her shopping, agree with what has been found, ask for alternatives, where they are and when they will be delivered.			
In this scenario the environmental management system is not only connected to sensors that control vehicle engines or the police, which in case of accidents can transfer information to the traffic control network to re-route traffic. The system is also able to alert individuals with allergies to certain types of pollutants when a dangerous threshold is reached. Individuals will be informed of the unhealthy atmosphere and can decide whether to go out or stay home.			
Forty minutes later Carmen goes downstairs onto the street, as her driver arrives. When Carmen gets into the car, the VAN system (Vehicle Area Network) registers her and by doing that she sanctions the payment systems to start counting.			
A micro-payment system will automatically transfer the amount into the e-purse of the driver when she gets out of the car.			
In the car, the dynamic route guidance system warned the driver of long traffic jams up ahead due to an accident. The system dynamically calculates alternatives together with trip times. One suggestion is to leave the car at a nearby 'park and ride' metro stop. Carmen and her driver park the car and continue the journey by metro. On leaving the car Carmen's payment is deducted according to duration and distance.	Problems in getting information from the syste.	The system knows that Carmen is deaf and all information is sent her as text.	The P-com and AmI are a relay centre for conversation between Carmen and the driver.
Out of the metro station and whilst walking the minutes to her job, Carmen is alerted by her PAN that a Chardonnay wine that she has previously identified as a preferred choice is on promotion that day. She decides to add it to her shopping list and uses the opportunity to tell her wearable when she plans to leave work and where she wants go. Carmen arrives at her job on time.		Carmen is alerted with vibrations and communication is made visually (text and images).	

In this scenario the environmental management system is not only connected to sensors that control vehicle engines or the police, which in case of accidents can transfer information to the traffic control network to re-route traffic. The system is also able to alert individuals with allergies to certain types of pollutants when a dangerous threshold is reached. Individuals will be informed of the unhealthy atmosphere and can decide whether to go out or stay home.	
On the way home the shared car system senses a bike on a dedicated lane approaching an intersection on their route. The driver is alerted and the system anyway gives preference to bikes, so a potential accident is avoided. A persistent high pressure for the last ten days has given fine weather but rising atmospheric pollutants. It is rush hour and the traffic density has caused pollution levels to rise above a control threshold. The city-wide engine control systems automatically lower the maximum speeds (for all motorised vehicles) and when the car enters a specific urban ring toll will be deducted via the Automatic Debiting System (ADS).	Audio signals from vehicles are transduced to tactile or visual signals by her P-com. The system can intervene if Carmen, for any reason, is not able to sense the signal.
Carmen arrives at the local distribution node (actually her neighbourhood corner shop) where she picks-up her goods. The shop has already closed. But the goods await Carmen in a smart delivery box. By getting them out, the system registers payment, and deletes the items from her shopping list. The list is complete. At home, her smart fridge screen will be blank.	
Coming home, AmI welcomes Carmen and suggests to telework the next day: a big demonstration is announced downtown	

Original scenario (Annette and Solomon)	Problems	Possible solutions	AmI opportunities
It is the plenary meeting of an environmental studies group in a local 'Ambient for Social Learning'. The group ranges from 10 to 75 years old. They share a common desire to understand the environment and environmental management. It is led by a mentor whose role it is to guide and facilitate the group's operation, but who is not necessarily very knowledgeable about environmental management. The plenary takes place in a room looking much like a hotel foyer with comfortable furniture pleasantly arranged. The meeting is open from 7.00-23.00 hours. Most participants are there for 4-6 hours. A large group arrives around 9.30 a.m. Some are scheduled to work together in real time and space and thus were requested to be present together (the ambient accesses their agendas to do the scheduling).			The cooperation of the P-com with AmI and the possibility of creating virtual spaces allows the optimisation of each working place for the individual user or a group of users with different capabilities
A member is arriving: as she enters the room and finds herself a place to work, she hears a familiar voice asking "Hello Annette, I got the assignment you did last night from home: are you satisfied with the results?" Annette answers that she was happy with her strategy for managing forests provided that she had got the climatic model right: she was less sure of this.	Communication with the mentor.	Annette is equipped with a speech recognition system able to translate voice into text. Alternatively, speech can be presented as movements of lips and/or sign language using animation software. If Annette is not able to speak, she can communicate using text or an automatic translation from sign languages to text or speech. Obviously this requires that gesture recognition systems take into account the need of recognizing sign languages.	These possibilities are created by the technological and infrastructural developments connected to the implementation of AmI.
Annette is an active and advanced student so the ambient says it might be useful if Annette spends some time today trying to pin down the problem with the model using enhanced interactive simulation and projection facilities. It then asks if Annette would give a brief presentation to the group. The ambient goes briefly through its understanding of Annette's availability and references for the day's work. Finally, Annette agrees on her work programme for the day.			
One particularly long conversation	Solomon introduces himself	If Salomon is deaf, the conversation	AmI is a completely automatic real-

takes place with Solomon who has just moved to the area and joined the group. The ambient establishes Solomon's identity; asks Solomon for the name of an ambient that 'knows' Solomon; gets permission from Solomon to acquire information about Solomon's background and experience in Environmental Studies. The ambient then suggests Solomon to join the meeting and to introduce himself to the group.		must be carried out according to the modalities described above.	time relay service with multiple input-output channels.
In these private conversations the mental states of the group are synchronised with the ambient, individual and collective work plans are agreed and in most cases checked with the mentor through the ambient. In some cases the assistance of the mentor is requested. A scheduled plenary meeting begins with those who are present. Solomon introduces himself.	Problems with introduction if Solomon is not able to speak.	Automatic translation from sign language to speech.	See previous comment.
Annette gives a 3-D presentation of her assignment. A group member asks questions about one of Annette's decisions and alternative visualisations are projected.	Problems with presentation	See previous considerations for communication with the mentor.	
During the presentation the mentor is feeding observations and questions to the ambient, together with William, an expert who was asked to join the	Problems in accessing contributions by William and the mentor.	An automatics captioning system (speech recognition) is used to convey comments to Annette and Solomon	

meeting. William, although several thousand miles away, joins to make a comment and answer some questions. The session ends with a discussion of how Annette's work contributes to that of the others and the proposal of schedules for the remainder of the day. The ambient suggests a schedule involving both shared and individual sessions			
During the day individuals and sub-groups locate in appropriate spaces in the ambient to pursue appropriate learning experiences at a pace that suits them. The ambient negotiates its degree of participation in these experiences with the aid of the mentor. During the day the mentor and ambient converse frequently, establishing where the mentor might most usefully spend his time, and in some cases altering the schedule. The ambient and the mentor will spend some time negotiating shared experiences with other ambients – for example mounting a single musical concert with players from two or more distant sites. They will also deal with requests for references / profiles of individuals. Time spent in the ambient ends by negotiating a homework assignment with each individual, but only after they have been informed about what the ambient expects to happen for the rest of the day and making appointments for next day or next time.			

Scenarios for people with spastic cerebral palsy

In the discussion, spasticity is considered only from the perspective of access to information and interpersonal communication. This will essentially include manipulation problems (that is control of fine manipulation operations necessary in the use of a keyboard or a mouse), fixation problems and difficulties in expressing herself using voice.

It is assumed that people are able to move around without using a wheelchair.

Original scenario (Maria)	Problems	Possible solutions	AmI opportunities
After a tiring long haul flight Maria passes through the arrivals hall of an airport in a Far Eastern country. She is travelling light, hand baggage only. When she comes to this particular country she knows that she can travel much lighter than a decade ago, when she had to carry a collection of different so-called personal computing devices (laptop PC, mobile phone, electronic organisers and sometimes beamers and printers). Her computing system for this trip is reduced to one highly personalised communications device, her 'P–Com' that she wears on her wrist.			Any reduction of weight of equipment can be very important for people who have problems in manipulation and moving around.
Maria calls the P-Com her 'key of keys' because it almost invisibly unlocks the doors she meets on her trip. It allows her to move around in an ambience that is shaped according to her needs and preferences. In the past travelling involved many different and complicated transactions with all sorts of different service vendors, often with gaps and incompatibilities between the different services. In the past few years a series of multi-service vendors (MSVs) have emerged offering complete packages of services linked to the P-Com that tailor the user's environment according to their preferences. User preferences are set up during an 'initiation period' during which personal agents (personal-servants or perservs) are instructed or learn how to obey their master's wishes. These agents are in continual negotiation with those of participating service providers (such as shops, rental companies, hotels and so on).			The possibility of delegating to an agent the transactions needed for organising a trip abroad can be very important for people who have problems of manipulation, fixation and interpersonal communication, even if manipulation of keyboards and pointing devices and speech communication can be aided by AmI.
A particular feature of this trip is that the country that Maria is visiting has since the previous year embarked on an ambitious ambient intelligence infrastructure programme. Thus her visa for the trip was self-arranged and		To simplify access to information (e.g. when fixation problems are present) navigation information may be conveyed through the P-Com (e.g. using speech).	

she is able to stroll through immigration without stopping because her P-Com is dealing with the ID checks as she walks.			
A rented car has been reserved for her and is waiting in an earmarked bay. The car opens as she approaches. It starts at the press of a button: she doesn't need a key. She still has to drive the car but she is supported in her journey downtown to the conference centre-hotel by the traffic guidance system that had been launched by the city government as part of the 'AmI-Nation' initiative two years earlier.	She cannot drive	She uses a taxi.	
Downtown traffic has been a legendary nightmare in this city for many years, and draconian steps were taken to limit access to the city. But Maria has priority access rights into the central cordon because she has a reservation in the car park of the hotel. Central access however comes at a premium price, in Maria's case it is embedded in a deal negotiated between her personal agent and the transaction agents of the car-rental and hotel chains. Her firm operates centralised billing for these expenses and uses its purchasing power to gain access at attractive rates. Such preferential treatment for affluent foreigners was highly contentious at the time of the introduction of the route pricing system and the government was forced to hypothecate funds from the tolling system to the public transport infrastructure in return.			
In the car Maria's teenage daughter comes through on the audio system. Amanda has detected from 'En Casa' system at home that her mother is in a place that supports direct voice contact. However, even with all the route guidance support Maria wants to concentrate on her driving and says that she will call back from the hotel,	Problems in expressing herself using speech.	In this case Maria has the advantage of being able to speak immediately with her daughter. If she has problems in expressing herself (which is not likely with the daughter), she can use a speech recognition system trained to the features of her voice (this asks for a	Speech recognition systems must be extended to be adaptable to the speech features of people with spastic cerebral palsy.

		speech recognition system really designed for all).	
Maria is directed to a parking slot in the underground garage of the newly constructed building of the Smar-tel Chain. She is met in the garage by the porter – the first contact with a real human in our story so far! He helps her with her luggage to her room.			
Her room adopts her 'personality' as she enters. The room temperature, default lighting and a range of video and music choices are displayed on the video wall.	The traditional remote control is not accessible.	Maria can use the P-Com emulating the remote control through the use of voice commands or "filtered" gestures.	For speech see previous comments. Gesture recognition systems must be able to to filter spastic movements.
Later on she 'localises' her presentation with the help of an agent that is specialised in advising on local preferences (colour schemes, the use of language). She stores the presentation on the secure server at headquarters back in Europe. In the hotel's seminar room where the sales pitch is take place, she will be able to call down an encrypted version of the presentation and give it a post presentation decrypt life of 1.5 minutes.	Problems in interacting with the editing system.	Keyboard and mouse emulators are part of the AmI environment,	
The hotel offers neutral third part hosting of presentations but Maria wants to be sure for her own peace of mind that some of the sensitive material in the presentation will not sit around on a 3rd party server for prying eyes to see. To do this work, Maria is using hardware provided by the hotel, but with security clearance and access to her personal home workspace guaranteed by her P-Com.			Importance given to security.
She goes downstairs to make her presentation…this for her is a high stress event. Not only is she performing alone for the first time, the clients concerned are well known	Problems in presentation.	Output No problems in the presentation, if Maria is able to speak. Otherwise she can use a speech synthesizer (see Demetrios scenario). In the	

to be tough players. Still, she doesn't actually have to close the deal this time. As she enters the meeting she raises communications access thresholds to block out anything but red-level 'emergency' messages.		discussion she can use a speech recognition system adapted to the features of her voice and automatic translation into text to be read or synthesised as speech. For interaction she can use a keyboard or mouse emulator, a speech synthesizer matched to the features of her voice or a gesture recognition system able to filter her spastic movements.	
The meeting is rough, but she feels it was a success. Coming out of the meeting she lowers the communication barriers again and picks up a number of amber level communications including one from her cardio-monitor warning her to take some rest now. The day has been long and stressing. She needs to chill out with a little meditation and medication. For Maria the meditation is a concert on the video wall and the medication….a large gin and tonic from her room's minibar.			

<table>
<tr><th>Original scenario (Dimitrios)</th><th>Problems</th><th>Possible solutions</th><th>AmI opportunities</th></tr>
<tr><td colspan="3">It is four o’clock in the afternoon. Dimitrios, a 32 year-old person working in a food- multinational, is taking a coffee at his office’s cafeteria, together with his boss and some colleagues. He doesn’t want to be excessively bothered during this pause. Nevertheless, all the time he is receiving and dealing with incoming calls and mails.

He is proud of ‘being in communication with mankind’: as are many of his friends and some colleagues. Dimitrios is wearing, embedded in his clothes, a ‘gateway’ or digital avatar of himself, familiarly known as ‘Digital Me’ or ‘D-Me’. A D-Me is both a learning device, learning about Dimitrios from his interactions with his environment, and an acting device offering communication, processing and decision-making functionality. Dimitrios has partly ‘programmed’ the D-Me himself, at a very initial stage: it was, he says, a great personal experience to formalise somehow his identity and the way he envisaged his relations. At the time, he thought he would ‘upgrade’ this initial data periodically. But he didn’t. He feels quite confident with his D-Me and relies upon its ‘intelligent PDA-like’ reactions.</td><td>D-Me is able to carry out most of normal transactions without making other people aware of Demetrios’ manipulation, fixation and speech limitations.</td></tr>
<tr><td colspan="4">Dimitrios has a ‘3P/3CAG D-Me’-it allows him to specify three privacy levels (3P) for personal data matched to three separate ‘closed access group’ (3CAG) memberships.</td></tr>
<tr><td colspan="4">At 4:10 p.m. following other calls of secondary importance - answered formally in a smoothly multilingual reproduction of Dimitrio’s voice and typical accent, a call from his wife is further analysed by his D-Me. The D-Me confronts available data registered from Dimitrios’ environment (voices, themes, location, other ‘patched’ objects) to match the situation with this private call (Dimitrios’ wife’s voice, theme, emotional level). In a first attempt, Dimitrios’ ‘avatar-like’ voice runs a brief conversation with Dimitrios’ wife, with the intention of negotiating a delay while explaining his current situation.

Simultaneously, Dimitrios’ D-Me has caught a message from an older person’s D-Me, located in the nearby metro station. This senior has left his home without his medicine and would feel at ease knowing where and how to access similar drugs in an easy way. He has addressed his query in natural speech to his D-Me. Dimitrios happens to suffer from similar health problems and uses the same drugs. Dimitrios’ D-Me processes the data available to offer information to the senior. It ‘decides’ neither to reveal Dimitrios’ identity (privacy level), nor to offer Dimitrios’ direct help (lack of availability), but to list the closest drug shops, alternative drugs and contacts to a self-help group and medical contacts nearby in case of emergency. This information is shared with the senior’s D-Me, rather than with the senior himself, to avoid useless information overload.</td></tr>
<tr><td colspan="4">The D-Me is equipped with voice, pattern and patch recognition capacity. It has to identify places and people, but also to register enough data to record the relevant events of Dimitrios’ life to process it in its DMe profile and offer it to other DMe’s.</td></tr>
</table>

<table>
<tr><td>Meanwhile his wife’s call is now interpreted by his D-Me as sufficiently pressing to mobilise Dimitrios. It ‘rings’ him using a pre-arranged call tone. Dimitrios takes up the call with one of the available ‘Displayphones’ in the cafeteria. Since the diffusion of D-Me, fewer people run around with mobile terminals. Public and private spaces have display terminals and your D-Me can point at the closest….functioning one!</td><td>Problems in communication.</td><td>If Dimitrios has problems in expressing himself (which is not likely with his wife), he can use a speech recognition system trained to the features of his voice (this asks for a speech recognition system really designed for all) and transmit text. Alternatively he can use the speech synthesizer of the P-com.</td><td></td></tr>
<tr><td colspan="4">Dimitrios’ wife hates his D-Me. She suspects him living parallel lives and whatever the practical aspects, she definitely would prefer having him right away on the phone. It has been a source of conflict from the start.</td></tr>
<tr><td colspan="3">The ‘emergency’ is about their child’s homework. While doing his homework their 9 year-old son is meant to offer some insights on everyday life in Egypt. In a brief 3-way telephone conference, Dimitrios offers to pass over the query to the D-Me to search for an available direct contact with a child in Egypt. Ten minutes later, his son is videoconferencing at home with a girl of his own age, and recording this real-time translated conversation as part of his homework. All communicating facilities have been managed by Dimitrios’ D-Me, even while it is still registering new data and managing other queries. The Egyptian correspondent is the daughter of a local businessman, well off and quite keen on technologies. Some luck (and income…) had to participate in what might become a longer lasting new relation.</td><td>Delegation communication to D-Me can be an opportunity to cover his possible problems.</td></tr>
<tr><td colspan="4">Managing a service while choosing the best telecommunication means for the videoconference forms part of the role of the D-Me.</td></tr>
</table>

Original scenario (Carmen)	Problems	Possible solutions	AmI opportunities
The driver is part of a carpooling scheme of the transport management systems in the urban area where Carmen lives. Advanced payment and transactions systems are in place, which are able to calculate the amount of money that goes to the driver and the amount that goes to the transport operators.			
It is a normal weekday morning. Carmen wakes and plans her travel for the day. She wants to leave for work in half an hour and asks AmI, by means of a voice command, to find a vehicle to share with somebody on her route to work. AmI starts searching the trip database and, after checking the willingness of the driver, finds someone that will pass by in 40 minutes. The in-vehicle biosensor has recognised that this driver is a non-smoker –one of Carmen requirements for trip sharing. From that moment on, Carmen and her driver are in permanent contact if wanted (e.g. to allow the driver to alert Carmen if he/she will be late). Both wear their personal area networks (PAN) allowing seamless and intuitive contacts	Possible communication problems	For the trip sharing, the Carmen's Aml informs the driver of her profile's data related to her disability, the destination and time details of the desire route, the way that he or she will recognise her at a meeting point, and the parameters for establishing (PAN) connection from the moment that they will agree. If Carmen has problems in expressing herself, she can use a speech recognition system trained to the features of her voice (this asks for a speech recognition system really designed for all) and transmit text. Alternatively she can use the speech synthesizer of the P-com (see Demetrios scenario). (Speech to speech translation)	Availability of efficient recognition of filtered gestures can be an important improvement for interaction with information systems. The same is true or the recognition of spastic speech.
Objects can be tracked through radio-frequency identification tags. These e-tags are very small, maximum of the size of a grain of rice and can be embedded in everyday objects. Everyone carrying a device equipped with a reader could access additional information and services relating to the tagged item.			This can be a very important opportunities to find objects for people with fixation problems
While taking her breakfast coffee Carmen lists her shopping since she will have guests for dinner tonight.	Need of alternative communication with the environment.	If Carmen has fixation problems, her P-com in communication with her e-fridge voices the recipe.	

She would like also to cook a cake and the e-fridge flashes the recipe. It highlights the ingredients that are missing: milk and eggs. She completes the shopping on the e-fridge screen and asks for it to be delivered to the closest distribution point in her neighbourhood. This can be a shop, the postal office or a franchised nodal point for the neighbourhood where Carmen lives. All goods are smart tagged, so that Carmen can check the progress of her virtual shopping expedition, from any enabled device at home, the office or from a kiosk in the street. All goods are smart tagged, so that Carmen can check the progress of her virtual shopping expedition, from any enabled device at home, the office or from a kiosk in the street. She can be informed during the day on her shopping, agree with what has been found, ask for alternatives, where they are and when they will be delivered.		The system concludes by listing the missing ingredients. If Carmen has problems in expressing herself, she can use a speech recognition system trained to the features of her voice (this asks for a speech recognition system really designed for all) and transmit text. If Carmen has problems of fixation, when she is connected to the shop, all the information stored in tags is translated in a properly encoded format for her to receive. Carmen may hear brief descriptions of the goods or a full presentation of a particular product or store shelf. Presentations may contain information for the product characteristics (size, colour, and weight), the packing, the price, potential offers or alternative selections and other information that will help her to make her choice.	
In this scenario the environmental management system is not only connected to sensors that control vehicle engines or the police, which in case of accidents can transfer information to the traffic control network to re-route traffic. The system is also able to alert individuals with allergies to certain types of pollutants when a dangerous threshold is reached. Individuals will be informed of the unhealthy atmosphere and can decide whether to go out or stay home.			
Forty minutes later Carmen goes downstairs onto the street, as her driver arrives. When Carmen gets into the car, the			AmI takes care of the Carmen's

<table>
<tr><td colspan="3">VAN system (Vehicle Area Network) registers her and by doing that she sanctions the payment systems to start counting.</td><td>mobility capabilities</td></tr>
<tr><td colspan="4">A micro-payment system will automatically transfer the amount into the e-purse of the driver when she gets out of the car.</td></tr>
<tr><td>In the car, the dynamic route guidance system warned the driver of long traffic jams up ahead due to an accident. The system dynamically calculates alternatives together with trip times. One suggestion is to leave the car at a nearby ‘park and ride’ metro stop. Carmen and her driver park the car and continue the journey by metro. On leaving the car Carmen’s payment is deducted according to duration and distance.</td><td></td><td>AmI is able to suggest the easier itinerary according to Carmen’s known mobility abilities.</td><td>AmI can act as an intelligent control system able to help Carmen in her mobility and navigation needs.</td></tr>
<tr><td colspan="4">Out of the metro station and whilst walking the minutes to her job, Carmen is alerted by her PAN that a Chardonnay wine that she has previously identified as a preferred choice is on promotion that day. She decides to add it to her shopping list and uses the opportunity to tell her wearable when she plans to leave work and where she wants go. Carmen arrives at her job on time.</td></tr>
<tr><td colspan="3">On the way home the shared car system senses a bike on a dedicated lane approaching an intersection on their route. The driver is alerted and the system anyway gives preference to bikes, so a potential accident is avoided. A persistent high pressure for the last ten days has given fine weather but rising atmospheric pollutants. It is rush hour and the traffic density has caused pollution levels to rise above a control threshold. The city-wide engine control systems automatically lower the maximum speeds (for all motorised vehicles) and when the car enters a specific urban ring toll will be deducted via the Automatic Debiting System (ADS).</td><td>This can be very useful if Carmen has limited mobility capabilities and is moving around alone.</td></tr>
<tr><td>Carmen arrives at the local distribution node (actually her neighbourhood corner shop) where she picks-up her goods. The shop has already closed. But the goods await Carmen in a smart delivery box. By getting them out, the system registers</td><td>Problems in manipulating heavy ggods.</td><td>The distribution node can be instructed to send goods home if necessary.</td><td></td></tr>
</table>

payment, and deletes the items from her shopping list. The list is complete. At home, her smart fridge screen will be blank.			
Coming home, AmI welcomes Carmen and suggests to telework the next day: a big demonstration is announced downtown.			

<table>
<tr><th>Original scenario (Annette and Solomon)</th><th>Problems</th><th>Possible solutions</th><th>AmI opportunities</th></tr>
<tr><td colspan="4">In the discussion spasticity is considered only from the perspective of access to information and interpersonal communication. This will essentially include manipulation problems (that is control of fine manipulation operations necessary in the use of a keyboard or a mouse), fixation problems and difficulties in expressing herself using voice.

It is assumed that Annette is able to move around without using a wheelchair.</td></tr>
<tr><td colspan="4">It is the plenary meeting of an environmental studies group in a local ‘Ambient for Social Learning’. The group ranges from 10 to 75 years old. They share a common desire to understand the environment and environmental management. It is led by a mentor whose role it is to guide and facilitate the group’s operation, but who is not necessarily very knowledgeable about environmental management. The plenary takes place in a room looking much like a hotel foyer with comfortable furniture pleasantly arranged. The meeting is open from 7.00-23.00 hours. Most participants are there for 4-6 hours. A large group arrives around 9.30 a.m. Some are scheduled to work together in real time and space and thus were requested to be present together (the ambient accesses their agendas to do the scheduling).</td></tr>
<tr><td>A member is arriving: as she enters the room and finds herself a place to work, she hears a familiar voice asking “Hello Annette, I got the assignment you did last night from home: are you satisfied with the results?” Annette answers that she was happy with her strategy for managing forests provided that she had got the climatic model right: she was less sure of this.</td><td></td><td>If Annette has problems in expressing herself, she can use a speech recognition system trained to the features of her voice (this asks for a speech recognition system really designed for all) and transmit text</td><td></td></tr>
<tr><td>Annette is an active and advanced student so the ambient says it might be useful if Annette spends some time today trying to pin down the problem with the model using</td><td>Problems with interactive simulation and projection facilities.</td><td>The system may be controlled with speech commands (the system is trained to the features of her voice - this asks for a speech recognition system really designed for all) or</td><td>Design for all specifications must be introduced in the implementation of AmI.</td></tr>
</table>

enhanced interactive simulation and projection facilities. It then asks if Annette would give a brief presentation to the group. The ambient goes briefly through its understanding of Annette's availability and references for the day's work. Finally, Annette agrees on her work programme for the day.		through a gesture recognition systems (with filtering of the spastic movements).	
One particularly long conversation takes place with Solomon who has just moved to the area and joined the group. The ambient establishes Solomon's identity; asks Solomon for the name of an ambient that 'knows' Solomon; gets permission from Solomon to acquire information about Solomon's background and experience in Environmental Studies. The ambient then suggests Solomon to join the meeting and to introduce himself to the group.			
In these private conversations the mental states of the group are synchronised with the ambient, individual and collective work plans are agreed and in most cases checked with the mentor through the ambient. In some cases the assistance of the mentor is requested. A scheduled plenary meeting begins with those who are present. Solomon introduces himself.	Problems of expression in private communications.	If she has problems in expressing herself, she can use a speech recognition system trained to the features of her voice.	
Annette gives a 3-D presentation of her assignment. A group member asks questions about one of Annette's decisions and alternative visualisations are projected.	Problems with presentation.	Output No problems arise in the presentation if Annette is able to speak. Otherwise, she can use a speech synthesizer (see Demetrios scenario). In the discussion she can use a speech recognition system adapted to the features of his voice and automatic translation into text to be	

<table>
<tr><td></td><td></td><td>read or synthesised as speech.</td><td></td></tr>
<tr><td colspan="4">During the presentation the mentor is feeding observations and questions to the ambient, together with William, an expert who was asked to join the meeting. William, although several thousand miles away, joins to make a comment and answer some questions. The session ends with a discussion of how Annette's work

contributes to that of the others and the proposal of schedules for the remainder of the day. The ambient suggests a schedule involving both shared and individual sessions.

During the day individuals and sub-groups locate in appropriate spaces in the ambient to pursue appropriate learning experiences at a pace that suits them. The ambient negotiates its degree of participation in these experiences with the aid of the mentor. During the day the mentor and ambient converse frequently, establishing where the mentor might most usefully spend his time, and in some cases altering the schedule. The ambient and the mentor will spend some time negotiating shared experiences with other ambients – for example mounting a single musical concert with players from two or more distant sites. They will also deal with requests for references / profiles of individuals. Time spent in the ambient ends by negotiating a homework assignment with each individual, but only after they have been informed about what the ambient expects to happen for the rest of the day and making appointments for next day or next time.</td></tr>
</table>

Scenarios for people moving in a wheelchair

In the discussion only problems from the perspective of access information and interpersonal communication are considered.

<table>
<tr><th>Original scenario (Maria)</th><th>Problems</th><th>Possible solutions</th><th>AmI opportunities</th></tr>
<tr><td colspan="3">After a tiring long haul flight Maria passes through the arrivals hall of an airport in a Far Eastern country. She is travelling light, hand baggage only. When she comes to this particular country she knows that she can travel much lighter than a decade ago, when she had to carry a collection of different so-called personal computing devices (laptop PC, mobile phone, electronic organisers and sometimes beamers and printers). Her computing system for this trip is reduced to one highly personalised communications device, her ‘P–Com’ that she wears on her wrist.</td><td>Any reduction of weight of equipment can be very important for people who have problems in moving around.</td></tr>
<tr><td colspan="4">Maria calls the P-Com her ‘key of keys’ because it almost invisibly unlocks the doors she meets on her trip. It allows her to move around in an ambience that is shaped according to her needs and preferences. In the past travelling involved many different and complicated transactions with all sorts of different service vendors, often with gaps and incompatibilities between the different services. In the past few years a series of multi-service vendors (MSVs) have emerged offering complete packages of services linked to the P-Com that tailor the user’s environment according to their preferences. User preferences are set up during an ‘initiation period’ during which personal agents (personal-servants or perservs) are instructed or learn how to obey their master’s wishes. These agents are in continual negotiation with those of participating service providers (such as shops, rental companies, hotels and so on).</td></tr>
<tr><td colspan="4">A particular feature of this trip is that the country that Maria is visiting has since the previous year embarked on an ambitious ambient intelligence infrastructure programme. Thus her visa for the trip was self-arranged and she is able to stroll through immigration without stopping because her P-Comm is dealing with the ID checks as she walks.</td></tr>
<tr><td>A rented car has been reserved for her and is waiting in an earmarked bay. The car opens as she approaches. It starts at the press of a button: she doesn’t need a key. She still has to drive the car but she is supported in her journey downtown to the conference centre-hotel by the traffic guidance system that had been launched by the city government as</td><td>Maria cannot drive a normal car.</td><td>Her agent has negotiated with the car renting company the availability of a car adapted to her needs.

Alternatively she can use a taxi.</td><td></td></tr>
</table>

<table>
<tr><td>part of the ‘AmI-Nation’ initiative two years earlier.</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">Downtown traffic has been a legendary nightmare in this city for many years, and draconian steps were taken to limit access to the city. But Maria has priority access rights into the central cordon because she has a reservation in the car park of the hotel. Central access however comes at a premium price, in Maria’s case it is embedded in a deal negotiated between her personal agent and the transaction agents of the car-rental and hotel chains. Her firm operates centralised billing for these expenses and uses its purchasing power to gain access at attractive rates. Such preferential treatment for affluent foreigners was highly contentious at the time of the introduction of the route pricing system and the government was forced to hypothecate funds from the tolling system to the public transport infrastructure in return.</td></tr>
<tr><td>In the car Maria’s teenage daughter comes through on the audio system. Amanda has detected from ‘En Casa’ system at home that her mother is in a place that supports direct voice contact. However, even with all the route guidance support Maria wants to concentrate on her driving and says that she will call back from the hotel</td><td></td><td>If Maria uses a taxi, she has the advantage of being able to speak immediately with her daughter.</td><td></td></tr>
<tr><td colspan="4">Maria is directed to a parking slot in the underground garage of the newly constructed building of the Smar-tel Chain. She is met in the garage by the porter – the first contact with a real human in our story so far! He helps her with her luggage to her room.</td></tr>
<tr><td colspan="3">Her room adopts her ‘personality’ as she enters. The room temperature, default lighting and a range of video and music choices are displayed on the video wall.</td><td></td></tr>
<tr><td colspan="4">Later on she ‘localises’ her presentation with the help of an agent that is specialised in advising on local preferences (colour schemes, the use of language). She stores the presentation on the secure server at headquarters back in Europe. In the hotel’s seminar room where the sales pitch is take place, she will be able to call down an encrypted version of the presentation and give it a post presentation decrypt life of 1.5 minutes.</td></tr>
<tr><td colspan="4">The hotel offers neutral third part hosting of presentations but Maria wants to be sure for her own peace of mind that some of the sensitive material in the presentation will not sit around on a 3rd party server for prying eyes to see. To do this work, Maria is using hardware provided by the hotel, but with security clearance and access to her personal home workspace guaranteed by her P-Com.</td></tr>
<tr><td colspan="4">She goes downstairs to make her presentation…this for her is a high stress event. Not only is she performing alone for the first time, the clients concerned are well known to be tough players. Still, she doesn’t actually have to close the deal this time. As she enters the meeting she raises communications access</td></tr>
</table>

thresholds to block out anything but red-level ‘emergency’ messages.
The meeting is rough, but she feels it was a success. Coming out of the meeting she lowers the communication barriers again and picks up a number of amber level communications including one from her cardio-monitor warning her to take some rest now. The day has been long and stressing. She needs to chill out with a little meditation and medication. For Maria the meditation is a concert on the video wall and the medication….a large gin and tonic from her room’s minibar.

<table>
<tr><th>Original scenario (Dimitrios)</th><th>Problems</th><th>Possible solutions</th><th>AmI opportunities</th></tr>
<tr><td colspan="4">It is four o'clock in the afternoon. Dimitrios, a 32 year-old person working in a food- multinational, is taking a coffee at his office's cafeteria, together with his boss and some colleagues. He doesn't want to be excessively bothered during this pause. Nevertheless, all the time he is receiving and dealing with incoming calls and mails.

He is proud of 'being in communication with mankind': as are many of his friends and some colleagues. Dimitrios is wearing, embedded in his clothes, a 'gateway' or digital avatar of himself, familiarly known as 'Digital Me' or 'D-Me'. A D-Me is both a learning device, learning about Dimitrios from his interactions with his environment, and an acting device offering communication, processing and decision-making functionality. Dimitrios has partly 'programmed' the D-Me himself, at a very initial stage: it was, he says, a great personal experience to formalise somehow his identity and the way he envisaged his relations. At the time, he thought he would 'upgrade' this initial data periodically. But he didn't. He feels quite confident with his D-Me and relies upon its 'intelligent PDA-like' reactions.</td></tr>
<tr><td colspan="4">Dimitrios has a '3P/3CAG D-Me'-it allows him to specify three privacy levels (3P) for personal data matched to three separate 'closed access group' (3CAG) memberships.</td></tr>
<tr><td colspan="4">At 4:10 p.m. following other calls of secondary importance - answered formally in a smoothly multilingual reproduction of Dimitrio's voice and typical accent, a call from his wife is further analysed by his D-Me. The D-Me confronts available data registered from Dimitrios' environment (voices, themes, location, other 'patched' objects) to match the situation with this private call (Dimitrios' wife's voice, theme, emotional level). In a first attempt, Dimitrios' 'avatar-like' voice runs a brief conversation with Dimitrios' wife, with the intention of negotiating a delay while explaining his current situation.

Simultaneously, Dimitrios' D-Me has caught a message from an older person's D-Me, located in the nearby metro station. This senior has left his home without his medicine and would feel at ease knowing where and how to access similar drugs in an easy way. He has addressed his query in natural speech to his D-Me. Dimitrios happens to suffer from similar health problems and uses the same drugs. Dimitrios' D-Me processes the data available to offer information to the senior. It 'decides' neither to reveal Dimitrios' identity (privacy level), nor to offer Dimitrios' direct help (lack of availability), but to list the closest drug shops, alternative drugs and contacts to a self-help group and medical contacts nearby in case of emergency. This information is shared with the senior's D-Me, rather than with the senior himself, to avoid useless information overload.</td></tr>
<tr><td colspan="4">The D-Me is equipped with voice, pattern and patch recognition capacity. It has to identify places and people, but also to register enough data to record the relevant events of Dimitrios' life to process it in its DMe profile and offer it to other DMe's.</td></tr>
<tr><td colspan="4">Meanwhile his wife's call is now interpreted by his D-Me as sufficiently pressing to mobilise Dimitrios. It 'rings' him using a pre-arranged call tone. Dimitrios takes up the call with one of the available 'Displayphones' in the cafeteria. Since the diffusion of D-Me, fewer people run around with mobile</td></tr>
</table>

terminals. Public and private spaces have display terminals and your D-Me can point at the closest….functioning one!
Dimitrios' wife hates his D-Me. She suspects him living parallel lives and whatever the practical aspects, she definitely would prefer having himright away on the phone. It has been a source of conflict from the start.
The 'emergency' is about their child's homework. While doing his homework their 9 year-old son is meant to offer some insights on everyday life in Egypt. In a brief 3-way telephone conference, Dimitrios offers to pass over the query to the D-Me to search for an available direct contact with a child in Egypt. Ten minutes later, his son is videoconferencing at home with a girl of his own age, and recording this real-time translated conversation as part of his homework. All communicating facilities have been managed by Dimitrios' D-Me, even while it is still registering new data and managing other queries. The Egyptian correspondent is the daughter of a local businessman, well off and quite keen on technologies. Some luck (and income…) had to participate in what might become a longer lasting new relation.
Managing a service while choosing the best telecommunication means for the videoconference forms part of the role of the D-Me.

Original scenario (Carmen)	Problems for a person on a wheelchair	Possible solutions	AmI opportunities
The driver is part of a carpooling scheme of the transport management systems in the urban area where Carmen lives. Advanced payment and transactions systems are in place, which are able to calculate the amount of money that goes to the driver and the amount that goes to the transport operators.			
It is a normal weekday morning. Carmen wakes and plans her travel for the day. She wants to leave for work in half an hour and asks AmI, by means of a voice command, to find a vehicle to share with somebody on her route to work. AmI starts searching the trip database and, after checking the willingness of the driver, finds someone that will pass by in 40 minutes. The in-vehicle biosensor has recognised that this driver is a non-smoker –one of Carmen requirements for trip sharing. From that moment on, Carmen and her driver are in permanent contact if wanted (e.g. to allow the driver to alert Carmen if he/she will be late). Both wear their personal area networks (PAN) allowing seamless and intuitive contacts	Need of special arrangements for travelling and meeting	For the trip sharing, Carmen's Aml informs the driver of her profile's data related to her disability, the destination and time details of the desire route, and the parameters for establishing (PAN) connection from the moment that they will agree. The driver is notified of Carmen's disability because a car able to accommodate a wheelchair is necessary.	
Objects can be tracked through radio-frequency identification tags. These e-tags are very small, maximum of the size of a grain of rice and can be embedded in everyday objects. Everyone carrying a device equipped with a reader could access additional information and services relating to the tagged item.			e-tags can be useful to avoid necessary movements at home to look for objects.
While taking her breakfast coffee Carmen lists her shopping since she will have guests for dinner tonight. She would like also to cook a cake and the e-fridge			

<table>
<tr><td colspan="4">flashes the recipe. It highlights the ingredients that are missing: milk and eggs. She completes the shopping on the e-fridge screen and asks for it to be delivered to the closest distribution point in her neighbourhood. This can be a shop, the postal office or a franchised nodal point for the neighbourhood where Carmen lives. All goods are smart tagged, so that Carmen can check the progress of her virtual shopping expedition, from any enabled device at home, the office or from a kiosk in the street. All goods are smart tagged, so that Carmen can check the progress of her virtual shopping expedition, from any enabled device at home, the office or from a kiosk in the street. She can be informed during the day on her shopping, agree with what has been found, ask for alternatives, where they are and when they will be delivered.</td></tr>
<tr><td colspan="4">In this scenario the environmental management system is not only connected to sensors that control vehicle engines or the police, which in case of accidents can transfer information to the traffic control network to re-route traffic. The system is also able to alert individuals with allergies to certain types of pollutants when a dangerous threshold is reached. Individuals will be informed of the unhealthy atmosphere and can decide whether to go out or stay home.</td></tr>
<tr><td colspan="3">Forty minutes later Carmen goes downstairs onto the street, as her driver arrives. When Carmen gets into the car, the VAN system (Vehicle Area Network) registers her and by doing that she sanctions the payment systems to start counting.</td><td>AmI can advice about unforeseeable problems to reach the meeting point, e.g. objects that can impede movements with a wheelchair.</td></tr>
<tr><td colspan="4">A micro-payment system will automatically transfer the amount into the e-purse of the driver when she gets out of the car.</td></tr>
<tr><td>In the car, the dynamic route guidance system warned the driver of long traffic jams up ahead due to an accident. The system dynamically calculates alternatives together with trip times. One suggestion is to leave the car at a nearby ‘park and ride’ metro stop. Carmen and her driver park the car and continue the journey by metro. On leaving the car Carmen’s payment is deducted according to duration and distance.</td><td></td><td>The UAN (Underground Network Area) registers Carmen as a client on wheelchair and suggests routes and paths that are suitable for her, so she could manage to be at work on time.</td><td>Carmen can be tracked and advised if there are problems for moving with a wheelchair.</td></tr>
<tr><td colspan="4">Out of the metro station and whilst walking the minutes to her job, Carmen is alerted by her PAN that a Chardonnay wine that she has previously identified as a preferred choice is on promotion that day. She decides to add it to her shopping list and uses the opportunity to tell her wearable when she plans to leave work and where she wants go. Carmen arrives at her job on time.</td></tr>
<tr><td colspan="3">On the way home the shared car system senses a bike on a dedicated lane approaching an intersection on their route. The driver is alerted and the system anyway gives preference to bikes, so a potential accident is avoided. A persistent</td><td>This can be very important when Carmen moves around with the</td></tr>
</table>

high pressure for the last ten days has given fine weather but rising atmospheric pollutants. It is rush hour and the traffic density has caused pollution levels to rise above a control threshold. The city-wide engine control systems automatically lower the maximum speeds (for all motorised vehicles) and when the car enters a specific urban ring toll will be deducted via the Automatic Debiting System (ADS).	wheelchair.
Carmen arrives at the local distribution node (actually her neighbourhood corner shop) where she picks-up her goods. The shop has already closed. But the goods await Carmen in a smart delivery box. By getting them out, the system registers payment, and deletes the items from her shopping list. The list is complete. At home, her smart fridge screen will be blank.	
Coming home, AmI welcomes Carmen and suggests to telework the next day: a big demonstration is announced downtown.	

<table>
<tr><th>Original scenario (Annette and Solomon)</th><th>Problems for a person on a wheelchair</th><th>Possible solutions</th><th>AmI opportunities</th></tr>
<tr><td colspan="4">In the discussion only problems from the perspective of access information and interpersonal communication are considered.</td></tr>
<tr><td colspan="3">It is the plenary meeting of an environmental studies group in a local ‘Ambient for Social Learning’. The group ranges from 10 to 75 years old. They share a common desire to understand the environment and environmental management. It is led by a mentor whose role it is to guide and facilitate the group’s operation, but who is not necessarily very knowledgeable about environmental management. The plenary takes place in a room looking much like a hotel foyer with comfortable furniture pleasantly arranged. The meeting is open from 7.00-23.00 hours. Most participants are there for 4-6 hours. A large group arrives around 9.30 a.m. Some are scheduled to work together in real time and space and thus were requested to be present together (the ambient accesses their agendas to do the scheduling).</td><td>The meeting space is organised in order to favour movement and access to information by people moving on a wheelchair.</td></tr>
<tr><td colspan="4">A member is arriving: as she enters the room and finds herself a place to work, she hears a familiar voice asking “Hello Annette, I got the assignment you did last night from home: are you satisfied with the results?” Annette answers that she was happy with her strategy for managing forests provided that she had got the climatic model right: she was less sure of this.</td></tr>
<tr><td>Annette is an active and advanced student so the ambient says it might be useful if Annette spends some time today trying to pin down the problem with the model using enhanced interactive simulation and projection facilities. It then asks if Annette would give a brief presentation to the group. The ambient goes briefly through its understanding of Annette’s availability and references for the day’s work. Finally, Annette agrees on her work programme for the day.</td><td>Problems in accessing interaction peripherals.</td><td>Position of screens and input peripherals can be adapted for a person on a wheelchair.</td><td></td></tr>
<tr><td colspan="4">One particularly long conversation takes place with Solomon who has just moved to the area and joined the group. The ambient establishes Solomon’s identity; asks Solomon for the name of an ambient that ‘knows’ Solomon; gets permission from Solomon to acquire information about Solomon’s background</td></tr>
</table>

and experience in Environmental Studies. The ambient then suggests Solomon to join the meeting and to introduce himself to the group.
In these private conversations the mental states of the group are synchronised with the ambient, individual and collective work plans are agreed and in most cases checked with the mentor through the ambient. In some cases the assistance of the mentor is requested. A scheduled plenary meeting begins with those who are present. Solomon introduces himself.
Annette gives a 3-D presentation of her assignment. A group member asks questions about one of Annette's decisions and alternative visualisations are projected.
During the presentation the mentor is feeding observations and questions to the ambient, together with William, an expert who was asked to join the meeting. William, although several thousand miles away, joins to make a comment and answer some questions. The session ends with a discussion of how Annette's work contributes to that of the others and the proposal of schedules for the remainder of the day. The ambient suggests a schedule involving both shared and individual sessions. During the day individuals and sub-groups locate in appropriate spaces in the ambient to pursue appropriate learning experiences at a pace that suits them. The ambient negotiates its degree of participation in these experiences with the aid of the mentor. During the day the mentor and ambient converse frequently, establishing where the mentor might most usefully spend his time, and in some cases altering the schedule. The ambient and the mentor will spend some time negotiating shared experiences with other ambients – for example mounting a single musical concert with players from two or more distant sites. They will also deal with requests for references / profiles of individuals. Time spent in the ambient ends by negotiating a homework assignment with each individual, but only after they have been informed about what the ambient expects to happen for the rest of the day and making appointments for next day or next time.

Appendix B - List of abbreviations and acronyms used in the text

A

AAC	Augmentative and Alternative Communication
AAL	Ambient Assisted Living
AAMI	Age-Associated Memory Impairment
ACD	Automatic Call Distribution
AD	Alzheimer's Disease
ADLs	Activities of Daily Living
ADS	Automatic Debiting System
AMG	Electro-Myogram
AmI	Ambient Intelligence
AmUIs	Ambient User Interfaces
API	Application Programming Interfaces
AT	Assistive Technology
ATC	Assistive Technology for Cognition

B

BAN	Body Area Network
BCI	Brain-Computer Interfaces
B-ISDN	Broadband Integrated Services Digital Network
BMT	Basic Mobile Terminal
BSL	British Sign Language

C

CAD	Computer Aided Design
CENELEC	European Committee for Electro-technical Standardization
CGI	Cell Global Identity
CM	Content Model
CMS	Content Management System
COTS	Commercial Off-The-Shelf
CPE	Continuous Professional Education
CSS	Cascading Style Sheets

D

DAISY	Digital Accessible Information System
DAT	Digital Audio Tape
DB	Database
DECT	Digital Enhanced Cordless Telecommunication
DfA	Design for All
D-Me	Digital Me
DSL	Digital Subscriber Line
DTV	Digital television

E

EASTIN	European Assistive Technology Information Network
EC	European Commission
ECG	Electro-Cardiograms
EDGE	Enhanced Data rates for GSM Evolution
EEG	Electro-Encephalograms
EGNOS	European Geostationary Navigation Overlay Service
EGPRS	Enhanced GPRS
EIB	European Installation Bus
EMG	Electromyograms
EMT	Extended Mobile Terminal

ESA	European Space Agency
ETACS	Extended Total Access Communications System
EU	European Union

F/G

GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile Communications
GSR	Galvanic Skin Resistance
GUI	Graphical User Interfaces

H

HSDPA	High Speed Downlink Packet Access
HTML	HyperText Markup Language

I

I/O	Input Output
IADL	Instrumental Activities of Daily Living
ICF	International Classification of Functioning, Disability and Health
ICT	Information Communication Technology
IM	Instant Messaging
IMS	IP Multimedia Subsystem
IP	Internet Protocol
IR	Infrared
ISDN	Integrated Services Digital Network
ISO	International Organization for Standardization
ISTAG	Information Society Technology Advisory Group
IT&T	Information Technology and Telecommunications
ITU	International Telecommunication Union

J/K

KNX	ISO standard

L

LCD	Liquid crystal display
LED	Light Emitting Diode
LR-WPAN	Low Rate Wireless Personal Area Network

M

MAPS	Memory Aiding Prompting System
MBWA	Mobile Broadband Wireless Access
MCI	Mild Cognitive Impairment
MDI	Multimedia Database Interface
MSV	Multi-Service Vendor

N

NAPCS	North American Product Classification System

O

OCR	Optical Character Recognition
OWL	Ontology Web Language

P

PAN	Personal Area Network
PC	Personal Computer
P-Com	Personal Communicator
PDA	Personal Digital Assistant
PSTN	Public Switched Telephone Network

Q/R

RDF	Resource Description Framework
RF	Radio Frequency

RFID	Radio-frequency identification
RIA	Rich Internet Applications
RSS	Really Simple Syndication

S

SIG	Special Interest Group
SiSi	Say It Sign It
SLC	Sensor Level Component
SMS	Short Message Service
SPARQL	Simple Protocol and RDF Query Language

T

TDD	Telecommunications Device for Deaf People
TEL	Technology-Enhanced Learning
TRS	Telecommunications Relay Service
TTY	Teletypewriter

U

UI	User Interface
UIMS	User Interface Management System
UMS	User Model Server
UMTS	Universal Mobile Telecommunications System
URL	Uniform Resource Locator
UV	Ultraviolet

V

VAN	Vehicle Area Network
VIVOCA	Voice-Input Voice-Output Communication Aid
VLE	Virtual Learning Environments
VRML	Virtual Reality Modelling Language

W

W3C	World Wide Web Consortium
WAAS	Wide Area Augmentation System
WAI	Web Accessibility Initiative
WAN	Wide Area Network
WCAG	Web Content Accessibility Guidelines
WCC	Wireless Communication Component
WCMS	Web Content Management Systems
WHO	World Health Organization
WLAN	Wireless Local Area Network
WMAN	Wireless Metropolitan Area Network
WPAN	Wireless Personal Area Network
WRAN	Wireless Regional Area Network
WSS	Wireless Sensor System
WYSIWYG	What You See Is What You Get

X/Y/Z µ

X10	Communication Standard
XML	Extensible Markup Language
XSLT	Extensible Stylesheet Language Transformations
µP	Microprocessor