4. Ambient Intelligence and implications for people with disabilities

4.1 Introduction

Ambient Intelligence (AmI)[1] is considered one of the possible instantiations of the emerging Information Society and a debate is going on about the possible impact of this emerging environment on the socio-economic integration of all citizens and, in particular, of older citizens and citizens with disabilities.

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 (design for all approach).

This chapter is a contribution toward the identification of new opportunities and challenges for the socio economic integration of older people and people with disabilities in an AmI environment. It is divided in two parts. The first part, starting from European development scenarios that describe possible activities to be carried out in future ambient intelligence environments, aims at anticipating to what degree and how people with different disabilities will be able to cope with the foreseen activities. People are considered as "immersed" in the described environments and a preliminary analysis is carried out about the potential integration of individuals who cannot see, hear, speak, manipulate objects, move around or have difficulties with memory, concentration or problem solving. The second part considers the ethical and legislative issues related to AmI and some of the technology necessary for its implementation. The discussed problems include privacy and transparency, product safety, and trust can be cited.

[1] In the literature, reference is made to the same concept but using other terms: for example, "ubiquitous computing" or "pervasive computing".

4.2 The ISTAG scenarios: a case study

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4.2.1 Introduction - The information society

It is commonly accepted that contemporary 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 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 which 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, 2001]. In this document, the vision of an information society is based on ambient intelligence as defined in the previous paragraph. 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 disabilities and older people, but, at the same time, new challenges for access to computer-based products and services.

4. Ambient Intelligence and implications for people with disabilities

The purpose of the present chapter 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. 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 and the expertise of the authors. The preliminary analysis presented in this chapter is meant to start discussion with people who are producing the new technology and are influencing its production at a policy level, according to the Design for All approach.

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 taken 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 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 dark scenarios [SWAMI 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.

The Chapter is organised as follows. Section 4.2.2 briefly discusses the ISTAG Scenarios and the related technologies. Section 4.2.3 introduces some methodological considerations regarding the performed analysis of scenarios. Section 4.2.4 discusses AmI technologies from the perspective of the potential advantages that they can introduce from the point of Assistive Technologies for disabled and elderly people. Subsequently, sections 4.2.5 and 4.2.6 provide an analysis, based on the reworked scenarios, of the potential advantages of AmI in terms of functionality and interaction respectively. Based on the previous discussions, section 4.2.7 put forwards the need for adopting a Design for All approach in the development of AmI technologies and of the AmI environment itself. Finally, section 4.2.8 points out the main challenges that emerge towards developing AmI environments accessible to, and useful for, all citizens.

4.2.2 ISTAG scenarios and related technology

Four scenarios were produced by ISTAG [Ducatel et al., 2001]. A short summary of them, pointing out the main activities of the involved characters, is included in this section in order to support the subsequent discussions. The complete scenarios are reported in appendix I.

4.2.2.1 The ISTAG scenarios in brief

Scenario 1: Maria - the road warrior

Maria is an employee of a big company who is travelling in a far-away country for business. She needs to navigate in an unknown environment (airport, city), to live and work in hotel rooms, to be supported in her business presentation, and to be in contact with her family and home environment. She is supported by a personal communicator, which is continuously in connection with the AmI environment, including the airport, the traffic guidance system in the city and the hotel room. The AmI system knows where she is located and is able to connect her not only with the surrounding environment, but also with any place in the world. The emphasis is on the seamless and intuitive support while moving around. Maria, thanks to AmI, can concentrate on the purpose of her trip without taking care of details, but still remaining always in control of the situation.

Scenario 2: Dimitrios - the digital me (D-Me)

Dimitrios is an employee of a multinational company. His main problem is to be connected continuously with people, even during the coffee break in which the scenario takes place, but without being disturbed if not really necessary. His communication agent, which learns from Dimitrios' way of dealing with different situations, is able to conduct most of his communications on his behalf, taking decisions on his behalf and speaking with his voice. When contacted by his wife about their child's homework, in order to find information about everyday life in another country (Egypt), a videoconference with a girl in Egypt, made possible by real-time translated conversation, is used to solve the problem. This scenario emphasises mainly the intelligence in the environment, which can capture, process and share information about human beings, and the expansion of human relationships. Interconnected D-Mes create networks, which allow people to be defended from outside interference and create new contacts and relationships.

Scenario 3: Carmen - traffic, sustainability and commerce

Carmen lives in a city where many services are available for taking care of everyday problems. She lives in an intelligent house that is interconnected with the network, and has access to an e-commerce system facilitating the purchase of everyday life goods. A shared-car system is available for her to go to work. This is part of the city system, which takes care of following her during travel and gives advice regarding traffic. The city can also regulate the behaviour of the vehicle, when necessary. In the scenario, the main emphasis is on an efficient and user friendly urban environment, through the use of very large-scale systems and services.

Scenario 4: Annette and Solomon - environment for social learning

Annette and Solomon are in an environment that is able to adapt itself to the needs of different learning groups and individuals with different ages, knowledge and interests about problems of environmental management. The environment can restructure itself also physically, offering, when necessary, interaction "islands" for different groups (the islands are virtual islands, where sound and visual spaces are confined) and very advanced presentation facilities (e.g., 3D holographic rendering). Contents, presentation speed, and complexity are controlled by AmI. The environment is aimed at the establishment of social relations in continuous interaction with the individuals. The scenario deals mainly with the empowerment of users in a learning environment and with the support of social processes, through the use of a communication network and a collective memory.

4.2.2.2 Key enabling technologies for AmI

From a technological perspective, the following 'Key Enabling Technologies' covering a broad range of ICT and smart material technologies, are considered as a basis for the emergence of an intelligent environment:

- *Embedded Intelligence*
- *Middleware and distributed systems*
- *IP mobile and wireless*
- *Multi-domain network management*
- *Converging core and access networks*
- *Micro and opto-electronics*
- *Trust and confidence enabling tools*
- *Cross-media content*
- *Multi-modal and adaptive interfaces*
- *Multi-lingual dialogue mode.*

Finally, the following requirements are considered as crucial for the development of technology concurring to the implementation of the AmI environment.

Requirement 1: Very unobtrusive hardware

Miniaturisation is assumed to produce the necessary enabling developments in micro and optical electronics. Molecular and atomic manipulation techniques will give rise to advanced and smart materials and nanotechnologies. In addition, the following are required: 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; smart materials that can change their characteristics and/or performance by stand alone intelligence or by networked interaction (e.g., smart clothing).

Design emphasis is supposed to be on human factors, so that the widespread embedding of computers produces a coherent AmI landscape, rather than just a proliferation of electronic devices.

Requirement 2: Seamless mobile/fixed web-based communications infrastructure

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. To deliver the full AmI vision (e.g., the 3-D real-time holographic rendering in the Annette and Solomon scenario) there will eventually be a need to move towards ultrafast optical processing in the fixed network. These networks will have to be seamless and dynamically reconfigurable. They will require more advanced techniques for dynamic network management (see Requirement 3).

Requirement 3: Dynamic and massively distributed device networks

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. Databases, whether centralised or distributed, should be accessible on demand from anywhere in the system. This implies: new computer and communications architectures, new systems software that can adapt to changing hardware configurations, the development of networked embedded intelligence and distributed data management and storage systems. Key to this aspect of AmI will be the development of middleware and agent technologies (Requirement 4).

Requirement 4: Natural human interfaces

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 real time middleware that can operate across domains to very general levels. These techniques will be equally important for developing intuitive machine to machine interaction, which are supposed to be multimodal (multi-user, multilingual, multi-channel and multipurpose) using speech, gesture, and pattern recognition. It should also be adaptive to user requirements providing context sensitive interfaces, information filtering and presentation, and cross-media content.

In the scenarios, voice, gesture and automatic identification and localisation are implicitly used to synchronise systems, so that services are available on tap when people require them.

Requirement 5: Dependability and security

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.

4.2.3 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 integration 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 integration or segregation of people in the emerging information society.

Instead, as previously stated, 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)"[2], 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 integration.

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" [WHO, 2001]. 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).

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). An example is given in appendix II, where for presentational reasons, the activities of column 1 come under the heading "original scenario" (in black) and columns 2, 3 and come under the headings "problems", Possible solutions and AmI opportunities respectively (in colour). 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.

[2] http://www3.who.int/icf/icftemplate.cfm

Due 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 integration in the information society, it is impossible to analyse all possible combinations corresponding to the ICF classification. Therefore, a set of examples are worked out, using some typical profiles concerning activity limitations in connection with the activities foreseen in the ISTAG scenarios.

Five different 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. Cognitive resources are crucial for successful and independent living. Cognition comprises human information processing functions and domains that allow people 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. Less severe forms of cognitive impairments are classified as age-associated memory impairment (AAMI) or mild cognitive impairment (MCI). Regardless of severity, cognitive impairments result in diminution of social contact, leading 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, 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 been 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.

4.2.4 New technology, systems and services

Traditionally, the problem of integration of people with activity limitations has been tackled through an adaptation approach, whereby systems and services are adapted after development to the needs of different user groups and/or the abilities of people are augmented with the use of assistive technologies. In section 4.2.7, the limitations of this approach will be discussed, particularly with reference to the new technological developments, advocating a new approach, namely the design for all approach.

However, before delving in the general analysis of the scenarios, it is useful to comment briefly 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. As a matter of fact, 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 to 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. Voice synthesis and recognition can be considered as a simple example. For recognition, the set goal 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). 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 disabilities. 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 elderly 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 in 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 disability 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 interface 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).

4.2.5 The environment as a general facilitator

So far, as already mentioned, the integration of people with activity limitations has been based on some complementary approaches: adaptation of systems addressing the needs of individual user groups (e.g., 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 integration, while section 4.2.6 deals with issues related to interaction.

4.2.5.1 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, for 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).

4.2.5.2 Relay services

Another type of service (relay services) of interest for people who cannot hear/and or speak is 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 be a default facility if the environment is developed following with a design for all approach (see section 4.2.7). Alternatively, a personal communicator, such as the one described in the Dimitrios' scenario, can be used as a personal relay service.

4.2.5.3 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 possibility, 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, 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.

4.2.5.4 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 in real time 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). 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. 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[3] or real dog. If she has cognitive problems, AmI can guide her to the meeting point.

4.2.5.5 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.

[3] 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.

4.2.5.6 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 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.

4.2.5.7 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).

4.2.5.8 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.

4.2.6 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 can 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. 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 of 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 the 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.

4.2.7 Design for All in the context of AmI

It is commonly accepted, also officially in political European documents [European Council, 2000; i2010], that the emerging information society will have to be universally accessible to all citizens. These include people who have functional, sensorial or cognitive limitations due to disabilities or age. In the same documents, explicit reference is made to the need of developing the new society (in terms of technology as well as services and applications) using a Design for All approach. 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 [Stephanidis, 1998], [Stephanidis, 1999], [Stephanidis, 2001].

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 often criticized on the basis of various arguments. In particular, there is a line of argumentation raising the concern that "many ideas that are supposed to be good for everybody aren't good for anybody" [Lewis& Rieman, 1994 - Section 2.1, Paragraph 3]. However, Design for All in the context of Information Society Technologies is not to be conceived 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, and critical property of interactive artifacts becomes their capability for intelligent adaptation and personalisation. Clearly, in a complex and dynamically evolving technological environment such as AmI, accessibility and usability by users with different characteristics and requirements cannot be addressed once the main building components of the new environment are in place. Instead, the need arises for more proactive approaches, such as Design for All, which can optimally exploit the adaptation and personalisation capabilities built-in in the environment.

In such a context, therefore the concepts of Universal Access and Design for All acquire critical importance towards streamlining accessibility into the new technological environment through generic solutions, and the requirement emerges of redefining the role and scope of assistive technologies in the new environment emerges [Emiliani & Stephanidis, 2005].

The point made in this chapter is that the two approaches can be considered as complementary and converging towards the creation of a more accessible information society through the continuous redefinition of problems in accordance with the developments of both fields, with the overall objective of producing barrier-free technologies. Complementarity and convergence are intended both at a specific and at a general level. At a specific level, 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, and therefore Assistive Technologies are necessary for specific cases. At a general level 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 can thus be addressed through an evolutionary approach. In the shorter term, the development of ambient intelligence can be supported by a technology which enhances the possibilities offered by Assistive Technology, merging in the medium term into 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 taken into account proactively during the design phase. Through such an evolutionary approach, Design for All emerges not as an abstract methodology, but as a necessary and efficient approach for maximising the potential advantages of introducing new technologies, and for minimising inherent risks of the increasing exclusion and segregation of specific groups of people. The effectiveness of this approach is essentially due to the fundamental fact that the core of the Design for All approach combines user-centeredness with automatic adaptation and personalisation.

4.2.8 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 integration 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 integration 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 will 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 disabilities 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 effected 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.

4.2.9 Conclusions

From the preliminary analysis of the possible impact of the development of the Information Society as an Ambient Intelligence environments, it seems that if the new technology is developed and deployed taking on board the needs, requirements and preferences of all potential users, i.e., all the citizens of the emerging Information Society, and if ethical problems are taken into account, the emerging situation could be an opportunity for favouring socio-economic integration.

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4.3 Ethical and legislative issues with regard to Ambient Intelligence

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4.3.1 Introduction

The scenarios discussed by COST 219ter demonstrate the potential benefits of the development of Ambient Intelligence (AmI) for people with disabilities (see sections 4.1 & 4.2). They show how the technology can assist people with disabilities in their day to day living, allowing more access to services and information than ever before through the interaction with their environment and the automation of tasks. However, these advances bring with them their own difficulties, for example, with the storage of personal information and the ethical issues that arise from the automation of tasks.

Where AmI means for many of us an increased comfort and better and faster functioning, the same issues can mean for people with disabilities a passing of a threshold between dependency (much need for human care support) and autonomous living. We could speak of enhanced leverage in case of a disability.

For example, firstly, people with a cognitive disability or any impairment related to mental and intellectual functioning might have great benefits from AmI. Travel support is one of the examples where AmI can assist in coping with a chaotic society. Secondly, smart homes while giving new possibilities for environment control can provide more independent living at home.

Thirdly, (human) care needed for daily living is, for people with disabilities, a matter of making them more dependent on human will and the costs can be relative high when compared with technological support. It is sometimes seen as a disadvantage that the human aspect in delivering care is then reduced as technology plays a greater role. This might be re-addressed as a design effort where AmI provides care functions in a user friendly and effective way. Fourthly, mental and physical health are closely related and the potential of AmI is to motivate and stimulate people to enhance their functionality and their way of coping with society. Based on intelligent analyses, AmI will stimulate people into learning and rehabilitation within the scope of their abilities. Fifthly, what all people need, and people with a disability even more so is secure and safe living. Telemedicine (often referred to as tele-monitoring) offers many possibilities for disabled and chronically ill persons as it is implemented in AmI surroundings.

The organisation of those AmI services is costly and needs a high level of common infrastructure. Thus it is expected that AmI will have opportunities for a rapid innovation and development when the larger institutions (social security, funds, hospitals, commercial companies etc.) include it in their future policy.

From a consumer point of view, the most relevant AmI scenario is represented by the concept of a smart house (see chapter 3) which is the combination of three elements: home automation, a communications network and intelligent control. Provided that consumer aspects are properly addressed, this can mean increased safety, comfort, convenience, security and energy savings for most groups of consumers, including elderly people and people with disabilities.

But there are also risks. Dark scenarios have been analysed in depth by Safeguards in a World of Ambient Intelligence (SWAMI) project. SWAMI scenarios are 'dark' since they include applications that go wrong or do not work as expected with the aim of highlighting the vulnerabilities and weaknesses and likely adverse impacts. Four dark scenarios have been elaborated around two axes that encompass both individual and societal concerns, on the one hand, and private and public concerns, on the other hand.

All citizens should have equal rights to benefit from the new opportunities that AmI technologies will offer (equal rights and opportunities). This will promote the removal of direct and indirect discrimination, will also foster access to services and encourage targeted actions in favour of under-represented groups, such as people with disabilities and older persons.

In the following section some important issues with regard to Ambient Intelligence are discussed either from an ethical or legal point of view.

4.3.2 Access to terminal equipment and services

Accessibility is a fundamental requirement for technology from a human point of view. Applications of AmI can mean access to society, for example to transport, housing, working life and communication. Technologically, accessibility relates to user interfaces. With regard to AmI it is even more important than with regard to individual devices, because AmI can be the kind of system and a network where one cannot choose to be in or out.

Access to control devices and control is a key issue from the point of view of the individual. It concerns, for example, various personal devices, or in the field of services, alarm call services.

Therefore, accessibility is required in order to support the inclusive participation (user acceptance), awareness and learning of users. Thus, this point may embrace different sub points, such as equal rights and opportunities, usability (vs. complexity), training/education and dependability.

Usability will promote system design according to a user-centric approach. Better usability will then support easy learning (i.e. learning by observation), user control and efficiency, thus increasing satisfaction and, consequently, user acceptance.

Training/education will promote education programmes to learn how to use new technologies and will increase the user awareness about the different possibilities and choices offered by AmI technologies and associated devices. This action is useful to increase the feeling of control and the awareness on the possible uses and consequences of the technology, thus reducing any misunderstanding on how the technology works.

The dependability challenges are to be addressed by an effective implementation of AmI technologies by taking into account both technical constraints and harmonized human-machine interfaces. Technical constraints are for example the scale and pervasiveness of applications/services and volume of components, heterogeneity of technologies and diversity of life cycles, intelligence and autonomy. The harmonized human-machine interface mainly encompasses the compatibility between technology and human systems and the technology-push in terms of social impact. Thus, dependability is essential in order to address almost all facets of dependency leading to exclusion or discrimination.

A relevant field which is covered by legislation is telecommunications. Central to the legal framework are the telecommunications directives, especially the Directive on Radio and Telecommunication Terminals (RTTE) (see section 5.1).. However, for the time being, standardization is a more important tool in the promotion of accessibility. Standardization has a lot to say about control devices, which act as a link between a person and ambient intelligence.

Another often quoted important piece of legislation is the Universal Service Directive which states in relation to the a universal service in Article 3 in Chapter II that Member States shall ensure that the services set out in this Chapter are made available at the quality specified to all end-users in their territory, independently of geographical location, and, in the light of specific national conditions, at an affordable price. The Chapter, entitled 'Universal service obligations including social obligations', covers the provision of access at a fixed location, directory enquiry services and directories, public pay telephones and special measures for disabled users. Special measures to be used by Member States are to be targeted to ensure access to and affordability of publicly available telephone services, including access to emergency services, directory enquiry services and directories.

AmI could represent an entirely new way of using electrical installations, appliances and communication services, in a way that consumers are unaccustomed and unfamiliar with. If the technology is difficult for consumers to operate and maintain, some consumers will be disadvantaged, i.e. will not be able to enjoy the potential benefits (energy savings, integrated alarms, etc.) offered by the system. The groups, such as elderly people and people with disabilities, that might gain the most benefit from such systems, might not be able to operate them. Different groups of consumers may achieve different benefits (e.g. people with physical disabilities can use remote control to operate all devices in the home, as opposed to having to move to individual devices round the home to control them). So it is important that different consumer needs are addressed by Design for All principles.

When considering products and services that relate to the Information Society, then the term e-Accessibility is sometimes used to mean the integration of all users i.e. older people, people with disabilities and also people placed in impairing environments. This will only come about as a result of designing mainstream products and services to be accessible by as broad a range of users as possible.

4.3.3 Privacy and transparency

Is AmI watching you? It is a form of monitoring. It is collecting information. It is not only collecting pieces of information, but it is creating configurations of information.

Profiling activities are essential in order to achieve the objectives of delivery of services in an AmI environment. Profiling activities require a seamless collection and processing of a broad range of data from numerous sources which are related to a user's identity, his/her activities, characteristics and preferences in specific contexts.

In general profiling in AmI facilitates applications of interest to society enhancing social inclusion or enabling services making the everyday life easier. However, several social issues are stemming from profiling in AmI. The main issues related to privacy are:

- *Erosion of privacy: right balance between security and privacy. Profiling activity requires some monitoring or surveillance of the users for the detection of physical activity for example. Monitoring and surveillance may erode privacy. Perhaps most people view privacy as a right that can be sacrificed, at least to some extent, if it leads to greater security*

- *Erosion of individual liberties. Indeed, profiles can limit freedom of choice of users by confining them within the limited set of options on offer by the providers. Profiles tend to govern opaque decisions about individuals concerning their access to services, such as obtaining credit or a position*

- *Inadequate profiling caused by privacy invasion. Problems of inadequate profiling can occur with regard to two main situations: attribution conflicts in case of numerous users leading to misinterpretations of users' needs. However, some problems may stem from malicious actions (i.e. a kind of privacy invasion). Inadequate profiling may lead to discrimination, exclusion and victimisation.*

Individual persons want to know what personal information is stored, and why. They want to know whether the information is to be transferred somewhere, and who will be permitted to use it, and who will not. Another issue concerns how long information will be stored within systems. The questions are geared to what other people are allowed to know about you.

One of the great benefits of AmI is its versatility, and the many uses that the same information can have in interacting with indoor and outdoor environments. While the information will be obtained fairly, will it be possible to use the information for one single purpose, especially when it may have to be shared among a wide range of other 'trusted' networks? If the data is replicated, will all the data be kept up to date? It is possible to see someone's physical requirements changing due to a debilitating disease, but this change not being notified to parts of the extended network. Retaining information 'as long as necessary' will almost certainly be irrelevant, as the data will be used indefinitely on a day to day basis. One of the great challenges faced by AmI won't be technical, it will be the ability to abide by these guidelines.

What is privacy protection? Article 8 of the European Convention on Human Rights and Fundamental Freedoms (1950) states that all persons have the right of respect for their private and family life, their home and their correspondence. There shall be no interference by a public authority with the exercise of this right except such as in accordance with the law and as is necessary in a democratic society in the interests of national security, public safety or the economic well-being of the country, for the prevention of disorder or crime, for the protection of health or morals, or for the protection of the rights and freedoms of others.

In the field of Information Society, European Union law includes the Directive on the processing of personal data, the Directive on the protection of privacy and the processing of personal data in the telecommunications sector and Directive concerning the processing of personal data and the protection of privacy in the electronic communications sector. In addition, there is detailed national legislation in the Member States.

Article 8 the EU Charter of Fundamental Rights (2000) summarizes important principles:

1. *Everyone has the right to the protection of personal data concerning him or her*
2. *Such data must be processed fairly for specified purposes and on the basis of the consent of the person concerned or some other legitimate basis laid down by law. Everyone has the right of access to data which has been collected concerning him or her, and the right to have it rectified*
3. *Compliance with these rules shall be subject to control by an independent authority.*

Each European country has its own implementation of the EU directive on privacy and personal information, but they conform to the principles of the protection of data, fairness in processing the data, and access to the data held about them. Ireland's data protection guidelines are fairly typical, and are cited here to give an example of the difficulties that AmI faces:

1. *Obtain and process information fairly*
2. *Keep it only for one or more specified, explicit and lawful purposes*
3. *Use and disclose it only in ways compatible with these purposes*
4. *Keep it safe and secure*
5. *Keep it accurate, complete and up-to-date*
6. *Ensure that it is adequate, relevant and not excessive*
7. *Retain it for no longer than is necessary for the purpose or purposes*
8. *Give a copy of his/her personal data to that individual, on request.*

Hence, many interests are involved in the transfer of information. It is the task of legislation to balance these interests. The complexity of interests reveals that the legislation is also complicated.

It is the role of legislation to provide common solutions to ethical issues and conflicts of interests and to prescribe confidentiality or public access. As mentioned, with regard to AmI, many sectors of legislation can be relevant. Mail and telephone calls, but also health and social sectors are traditionally important fields.

Privacy in public electronic networks is protected by legislation. The Privacy and Electronic Communications Directive ensures that the protection of confidentiality is guaranteed for all forms of private communications over public electronic networks. Confidentiality is the main focus (Article 5). There are also legitimate reasons for having exceptions. A very specific example can be found in the field of telecommunications. Where the calling-line identification (CLI) is offered, the user must have the possibility of preventing CLI (Article 8). However, it is justified to override the suppression of CLI and location data in the case of emergency calls (Article 10 (b)).

This example shows that in different situations there are really different and sometimes conflicting interests. It is in fact one of the fundamental ideas of law that it balances different interests, with principles and rules. Hence, laws do not only have to link to ethics, but contribute to the functioning of a society.

The information profile of a person monitored within an ambient intelligent system can itself direct ambient intelligence and it should also be possible for a person in turn to control the profile. This leads to a moral requirement: It should be possible for persons to control and make choices concerning the functioning of ambient intelligence, e.g. concerning their own profiles or the system's operation. This is an implication of the moral principle of autonomy.

Those are the difficulties posed through the authorised use of the system. But what about the unauthorised access? Identity theft is already common on the internet. AmI works through the use of wireless technology, meaning that all information has to be broadcast. A worrying possibility is that someone may breach the security system, capture these details, and use them elsewhere. Careful design of the system becomes essential.

Although there are many difficulties with the adoption of AmI with regard to privacy and ethics, these problems are not insurmountable. In order to protect the privacy of the individual, a secure system for the broadcast of information is required.

Adherence to the data protection guidelines needs to be made explicit in the development of AmI systems. This would mean that a 'specified explicit purpose' can be agreed upon, that only the relevant information is stored or transmitted by the system. A regular review of the information needs to be built in, in order to ensure that information about a person is accurate, and to give the person an opportunity to request the removal of information from the system as required.

Critical data entering or leaving the system, for example via the smart house gateway, should be secure. The electronic system should ensure that filtering of incoming data (e.g. from the Internet) meets the consumers' requirement. The electronic system should ensure that critical outgoing data (e.g. credit card details, personal medical data and information related to personal security) is secure and adequately encrypted.

Privacy is the interest that individuals have in sustaining a 'personal space', free from interference by other people and organisations. It is an interest that has several dimensions:

- *privacy of the person. This is concerned with the integrity of the individual's body. Issues include compulsory immunisation, blood transfusion without consent, compulsory provision of samples of body fluids and body tissue, and compulsory sterilisation*
- *privacy of personal behaviour. This relates to all aspects of behaviour, but especially to sensitive matters, such as sexual preferences and habits, political activities and religious practices, both in private and in public places*
- *privacy of personal communications. Individuals claim an interest in being able to communicate among themselves, using various media, without routine monitoring of their communications by other persons or organisations*
- *privacy of personal data. Individuals claim that data about themselves should not be automatically available to other individuals and organisations, and, even where data is possessed by another party, the individual must be able to exercise a substantial degree of control over that data and its use.*

4.3.4 Product safety

What if something goes wrong? Who is behind ambient intelligence? Who can I contact if the system is not working?

A possible answer can be found in product liability. According to European legislation, a product is deemed safe once it conforms to specific Community provisions, national regulations or certain principles. The general safety requirement is imposed by the Directive on general product safety on any product put on the market for consumers or likely to be used by them, including all products that provide a service.

A product is deemed safe once it conforms to the specific Community provisions governing its safety. In the absence of such provisions, the product's compliance is determined in certain other ways.

Obligations have been laid on manufactures and distributors. The manufacturers must put on the market products that comply with the general safety requirement. They must also provide consumers with necessary information. Distributors are obliged to supply products that comply with general safety requirements, to monitor the safety of products on the market, and to provide the necessary documents to ensure that the products can be traced. If the manufacturers or distributors discover that a product is dangerous, they must notify the competent authorities, and if necessary, co-operate with them.

The Members States put in place structures that are responsible for monitoring a product's compliance with safety requirements and taking the necessary measures in this regard, e.g. prohibiting products that fail to comply from being marketed. The Member States can take restrictive measures by informing the Commission, which communicates the information to the other Member States.

There is also legislation on specific sectors. The Low Voltage Directive seeks to ensure that electrical equipment within certain voltage limits provides a high level of protection for European citizens.

Beyond these legal requirements there are also moral requirements. User involvement is important for the development of good products but it also has value in itself. It builds up trust in the production process. Products should correspond to the needs of users. Users themselves are the best experts in that. But in complicated technologies user involvement is not an easy task. There are methods for user involvement, but perhaps even more effort should be put to the development and dissemination of these methodologies.

Producers should thus listen to consumers. In addition to this co-operation, consumers have some other opportunities. They can make their choice in the market.

For the electrical and mechanical safety of appliances and home automation there are three situations to consider:

- *The inherent safety of the device as a stand-alone appliance or application. This is covered by the existing safety standards [CENELEC EN 60335-1: safety of domestic appliances (Low voltage directive)] and in many cases the device would be considered as an "unattended" appliance. (Note, those standards contain a clause that exclude the use of domestic appliances by "children and infirm people without supervision". This is contested by consumers associations and could be a problem in smart house standardisation for the "caring" aspects of smart houses)*
- *The safety of the device when used as a stand-alone automatic or remotely controlled application, but not as an integral part of a smart house. Here the safety mechanisms and detection systems have to be built into the device*
- *The safety of the device when controlled and operated as an integral part of the system. In this situation the safety mechanisms may be those of the house itself.*

This means that safety requirements in AmI may have to go beyond those required by the existing safety standards called up by current EU directives.

In addition to the above issues, consumers are also concerned with Electro Magnetic Compatibility issues that can affect compatibility. To comply with the EU directives [Directive 89/336/EEC on the approximation of the laws of the Member States relating to electromagnetic compatibility and RTTE Directive 1999/5] individual components have the "CE" mark to show compliance. Consumers will be reassured if they know that EMC could also be guaranteed for the whole AmI system, not just the component parts, this principal is not always addressed by the existing EMC standards. Many components in a system will be used in close proximity to each other and radio devices may share frequency bands. The EMC directive and standards do not always address close proximity use. Some components such as heart pacemakers, wheelchairs and other medical equipment will require special attention in this respect.

From a consumer's view, AmI technical solutions should be based on open standards; otherwise companies controlling the infrastructure will dictate the preconditions. In reality, the cost and complexity of such systems will inevitably result in a number of proprietary systems together with a degree of commercial vertical integration. Consumers may therefore find themselves financially or physically 'tied-in" to a system. Interoperability standards must exist to ensure consumers can change their system or service via the home 'gateway' without major redesign and appliance replacement or loss of functionality or safety.

4.3.5 Market

Who pays? This is always an important question. As ambient intelligence can refer to so many areas of application, like smart homes, environment control, monitoring systems, traffic information, etc., it is not possible to give an answer here. The point here is that this is an important question which should be made transparent.

In the market there is supply and demand. There is design, manufacturing, selling, buying, using. In many cases ambient intelligence is a very complicated product. In addition to ordinary roles in the market, AmI may add a challenge to mastering the whole system.

In addition to the question of getting money, there is a question that how the money is used. Public procurement describes a system how money is used. There is European legislation in regard to public procurement. Ensuring sufficient quality criteria in public procurement is also in the interests of the end-user.

There is a further dimension. An individual product, for example a walking aid, requires adjustment and maintenance. What is important for the user is not the product alone but the service where arranging a product for use is an essential part.

Hence, when thinking of AmI as a product, it can be arranged by the service provider and in the end it is financed by the user, via the price of a product or user fees or taxes. Some systems can be based on public financing as a part of a public infrastructure, e.g. traffic information. In some cases assistive devices can be financed by the public sector.

Public procurement is actually a remarkable market force. In Europe, public procurement in each of the 25 Member States must follow the rules outlined in the EU's Public Procurement Directives. The primary purpose of these Directives is to ensure that there is a properly functioning internal market so suppliers from any Member State can have equal access to the public procurement markets in any Member State. More recently attention has begun to be given to how these instruments can be used to further other objectives of public policy, including environmental and social objectives. In this context, there have now been revisions made to the Directives that, inter alia, encourage the inclusion of accessibility criteria in public procurement by the Member States (International workshop on accessibility requirements for public procurement in the ICT domain).

The preambles to the revised Directives [paragraph 29 of Directive 2004/18/EC and paragraph 42 of Directive 2004/17/EC] now state that: "Contracting authorities should, whenever possible, lay down technical specifications so as to take into account accessibility criteria for people with disabilities or design for all users." In addition, the specific Articles on technical specifications [Article 23, Paragraph 1 of Directive 2004/18/EC and Article 34, Paragraph 1 of Directive 2004/17/EC] now state that: "Whenever possible [these] technical specifications should be defined so as to take into account accessibility criteria for people with disabilities or design for all users" (International workshop on accessibility requirements for public procurement in the ICT domain).

4.3.6 Trust

Trust is based on many conditions which have been discussed in this chapter. AmI requires a user to 'trust' the IT systems around them. It is this trust that is the root of many of the potential difficulties. As everyone is aware, computers will do exactly as they are instructed, including implementing errors. Because of this danger, one question that must be asked is what can we trust these systems to do? If a system is relied upon to open doors automatically, systems need to be put in place to ensure that there are other means of carrying out this function. If there is an automatic emergency function, can it be guaranteed that it will work when it is required? And on what basis does it make the 'decision' to call? If an attempt at contact is made, and the person's 'me' electronic device refuses to allow contact, on what basis does it do this?

Indeed, trust is necessary for any technology dealing with information related to user's personal data and it is the basis of the users' willingness for their participation. Indeed, establishing public trust is a key point for any successful implementation. The trust concept encompasses different points, such as the user requirements, the trust model, the management of the trust and the solutions enabling trust. The notion of trust has not only technical aspects but also social, cultural and legal aspects. In the dark scenarios of SWAMI project, trust is raised in different connections: trust and confidence, lack of trust (from loss of control, unwillingness to provide some data, contextual misunderstandings) and honesty.

Also, if the system is set up for someone with disabilities, decisions are being made in some cases for people, and this in itself is an ethical issue. Procedures need to be put in place to ensure that if possible the person contributes to the making of these decisions, and if this is not possible that the decisions made are really in the interests of the end user affected.

Many consumers do not appreciate the holistic concept of AmI; instead they will understand separate parts (home automation or broadband internet being the most obvious). The industry and European governments need to provide information explaining the concepts for general education and to counter potential misleading media reports.

Trust of technology and services is needed, but even something more is needed. An organised society requires trust between persons. Trust requires privacy protection and confidentiality. On the other hand, trust requires transparency to a certain degree. The user must know the principles according to which data is transferred.

4.3.7 Ethically aware design guidelines

Many of the previously mentioned ethical issues may be rooted in the technical design and implementation of the intelligent environment. Some design decisions about what information about the user is required, how is that information stored, transmitted or processed, what kind of decisions are automatically taken by the system without human intervention, etc., very much condition the impact on privacy and personal autonomy produced by the system.

In most cases these decisions are taken for the sake of better efficiency of the system, ignoring non-technical aspects. After the completion of the design and implementation phases –maybe during the user testing or even after the deployment of the system– the impact over autonomy and privacy is detected. Frequently, these effects cannot be removed without a complete redesign of the system, leading to a situation where users must accept the system "as it is" or just reject it.

Designers adduce that they only need to cope with technical problems, leaving social and moral problems under the responsibility of policy makers, service providers, care givers, familiars, etc. But, if they were aware of existing regulations and basic principles, they would be able to avoid these effects.

Therefore, in order to prevent undesired ethical impacts, it is necessary to provide designers with ethical or moral guidelines that help them to avoid unnecessary collisions with users' civil rights. The need and convenience of inclusive and ethically aware design guidelines is studied and discussed by Abascal and Nicolle [Abascal and Nicolle, 2005].

Ethical guidelines are not yet well established and disseminated. Nevertheless, examples of good practice, compiled by diverse research groups, user associations, institutions, etc., may help people interested in developing ethical impact-free applications and systems. For instance, the effects of tagging systems on elderly people affected by dementia are carefully studied by Nicolle [Nicolle, 1998]. On the other hand, Casas et al., [Casas et al., 2006], analyse the type of information that can be stored and transmitted by indoor location systems for fragile elderly people in institutions, and provide useful design guidelines.

Several ethical issues in Ambient Intelligence environments do not only affect people with disabilities and elderly people as shown in [Bohn et al., 2005] and [Robinson et al., 2005]. For instance, the impact over user's privacy of location systems -and technical alternatives to decrease it- are recurrently discussed, by [Myles et al., 2003], [Beresford and Stajano, 2003], [Clarke, 1999], etc. Civil rights protection of common users would have evident benefits in protecting the rights of people with disabilities and elderly people. Nevertheless, some basic protective requirements, such as "informed consent", are hardly extensible to the case of people with cognitive restrictions, which require further discussion.

4.3.8 Conclusion

Below is a brief Strengths Weaknesses Opportunities Threats (SWOT) analysis summarising the issues and possibilities:

Strengths

- *Allows an end user more personal freedom, and better access to their environment*
- *Potential to give full access to places previously unavailable*
- *Increased safety, comfort, convenience, security.*

Weaknesses

- *Data is broadcast, open to interference*
- *Updating of the systems: possible that the information can become out of sync*
- *Computers will do what they are programmed to do, so are liable to make the incorrect choices in some situations.*

Opportunities

- *Improved security to ensure no interception of information*
- *Regular reviews to ensure customer satisfaction, relevant information*
- *Ability to review the 'automatic' decisions made by the system.*

Threats

Misuse of information

AmI benefits may be negated by numerous threats such as accidental or intentional misuse of the components of AmI systems (tags, sensors, readers, other smart devices and so on) and associated databases, and by a wide range of issues such as privacy and personal well-being (societal and ethical issues). Indeed, various issues related to pervasive security problems can lead to enlarged privacy violations committed by insiders and outsiders, e.g. misuses of databases associated with RFID tag information, or remote surveillance whenever AmI devices are vulnerable (lack of security guarantee).

The difference between misuse and abuse of data is that misuse refers to the case where an organisation for example does not protect its systems adequately and has its data stolen through a computer attack. Abuse refers to an organisation that sells personal data to a second one.

Illegal use of information

Danger of identity theft: most actions in everyday life carry identity information and to be able to perform them, people need to present identity for identification or authentication purposes. Hence, identity theft is becoming a very serious problem which compromises the safety of people and the integrity of the identity of each individual. The Internet and the increasing importance of electronic transactions and subsequent digital traces exacerbate the problem as it becomes easier for an identity thief to carry out fraud:

Incorrect decisions made automatically, without the awareness of the end user

Safety shortcomings.

These are some of the issues which should be addressed when developing AmI applications. However, human beings need other people who cannot be replaced by AmI. But sometimes technology can help in everyday life. Ethics is about the relationship between persons but can also be expected to say something about people when they use technology. It is important how technology is used: what can it be used for and how should it be developed? When agreement is reached in a parliament, it can turn into law. Ethical discussions, policies, guidelines and legislation are needed to overcome the challenges posed by Ambient Intelligence.

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