Grant Agreement: 248582

CARDIAC

Coordination Action in R&D in Accessible and Assistive ICT

FP7-Coordination Action

Deliverable D4.1:

Report with basic materials needed to support the SDDP-3 meeting

Date of this draft: 18/05/2012

Nature of Deliverable: public (PU)

Start date of Project: 01.03.2010

Duration: 36 months

Editors:

Pier Luigi Emiliani (CNR)
Laura Burzagli (CNR)
Iosif Klironomos (FORTH)

Executive summary

Telecommunication services for access to information and interpersonal communication are becoming an integral and important part of human activities.

Therefore it is important to discuss their accessibility, usability and usefulness. Are the offered functionalities really necessary and sufficient to grant access for all citizens to relevant information and interpersonal communication? Moreover, can they be used, when necessary, to support people in their everyday activities, for example favouring independent living, socialisation, leisure and so on?

The present document is mainly concerned with usability and usefulness of present and foreseen network services and applications and offers basic information necessary for starting discussion in a multidisciplinary environment. It is not a technical document, i.e. it does not discuss in depth technical implementations of services. Services and implementations are considered from the perspective of functionalities to be made available in the environment, according to widely available international documents dealing with societal changes connected to technological development.

Potential users are virtually observed while carrying out normal activities in the house or other environments through the development of simple living scenarios. Even if the environments and the activities are very general in nature, users observed in the environments are people with sensorial and motor activity limitations that could impede their access to information and interpersonal communication. This is due to the fact the people with activity limitations often stress the potential limits of technology forcing solutions that result in them being useful for all. Moreover, the design for all approach is based on the introduction of the needs, requirements and preferences of all users in the design specification of technology. Therefore these must be carefully elicited.

The Structured Dialogic Design Process (SDDP) is meant to point out and prioritize research and development activities that are deemed necessary by a multidisciplinary group of experts in order to increase the usability and usefulness of emerging services in the ambient intelligent environment for all citizens, including citizens with activity limitations.

List of contributors

Pier Luigi Emiliani	National Research Council	Italy
Laura Burzagli	National Research Council	Italy
Lorenzo Di Fonzo	National Research Council	Italy
Patrick Roe	Ecole Politechique Fedérale Lausanne	Switzerland
Mary T. Nolan	Central Remedial Clinic	Ireland
Iosif Klironomos	Foundation for Research and Technology - Hellas	Greece
John Gill	John Gill Technology Ltd	United Kingdom
Ilse Bierhoff	Stichting Smart Homes	Netherlands

Table of Contents

1. Introduction

Accessible and supportive network services are very important in allowing people's socio-economic integration in society. Therefore, it is crucial to discuss how developments in network technologies and services could impact their capability to support citizens in general and citizens with activity limitations in particular, in order to point out and prioritize research and development activities meant to reduce possible problems and maximize positive impact.

This is particularly important if one examines the demographics of people at risk of exclusion across Europe.

Table 1: Elderly and people with restrictions in EU countries

	Individuals restricted between 15 - 79	**Individuals restricted between 15 - 64, and all elderly population between 65-79**	**Total population between 15 - 79**	**Total population**
Belgium	722.973	1.912.357	8.261.946	10.511.382
Czech Republic	1.495.561	2.290.932	8.426.387	10.251.079
Denmark	668.066	1.130.746	4.195.426	5.427.459
Germany (including former GDR from 1991)	7.898.467	17.634.724	67.186.966	82.437.995
Estonia	150.931	288.714	1.098.607	1.344.684
Ireland	299.640	590.972	3.236.736	4.209.019
Greece	683.631	2.120.815	9.133.772	11.125.179
Spain	3.286.726	7.716.330	35.531.699	43.758.250
France	8.060.630	13.446.521	48.446.056	62.998.773
Italy	3.214.247	10.796.978	47.412.631	58.751.711
Cyprus	73.066	127.747	604.701	766.414
Lithuania	280.676	620.391	2.743.047	3.403.284
Luxembourg	20.169	66.271	367.294	469.086
Hungary	1.198.136	2.130.179	8.172.107	10.076.581
Malta	26.429	64.002	323.195	405.006
Netherlands	1.938.871	3.293.385	12.773.352	16.334.210
Austria	649.192	1.471.180	6.578.676	8.254.298
Portugal	1.773.726	2.655.483	8.497.952	10.569.592
Slovenia	365.280	521.286	1.656.777	2.003.358
Slovakia	426.694	837.171	4.365.236	5.389.180
Finland	1.087.448	1.453.236	4.141.397	5.255.580
Sweden	767.005	1.689.722	6.993.912	9.047.752
United Kingdom	8.324.487	13.411.968	46.998.916	60.409.918

	Individuals restricted between 15 - 79	Individuals restricted between 15 - 64, and all elderly population between 65-79	Total population between 15 - 79	Total population
Romania	1.121.332	3.473.712	17.698.764	21.610.213
Norway	572.752	915.812	3.521.926	4.640.219
EU	**45.106.133**	**90.660.635**	**358.367.478**	**449.450.222**

[Source: data inferred from (Eurostat 2006) and (Applica et al, 2007) (Ref: ATIS4ALL)]

In that context, the discussion in this meeting will be carried out according to the Structured Dialogic Design Process (SDDP), a methodology that supports democratic and structured dialogue among a group of stakeholders. SDDP is especially effective in resolving multiple conflicts of purpose and values, and in generating consensus on organizational and inter-organizational strategy.

The SDDP is specifically designed to assist non-homogeneous groups to deal with complex issues, in a reasonably limited amount of time. It enables the integration of contributions from individuals with diverse views, backgrounds and perspectives through a process that is structured, inclusive and collaborative. A group of participants, who are knowledgeable and have a stake in a particular situation are engaged in collectively developing a common framework of thinking based on consensus and shared understanding of the current and of a future ideal state of affairs.

The SDDP promotes focused communication among the participants in the design process and their ownership of and commitment in the outcome. Moreover, it produces roadmaps which are efficient and are supported by those who have developed them.

The purposes of the present document are the following:

- to summarise the features of networks today and their main utilisation;
- to identify their explicit use in supporting eInclusion (e.g. relay services);
- to construct a vision on how technology and network services could develop in the next 10 years;
- to discuss about the possible impact on the inclusion of citizens in the developing information society;
- to introduce a triggering question for the SDDP that can elicit the identification of possible problems and advantages in the foreseen developments.

The present document is not supposed to be technical, i.e. it does not present and discuss technical details of equipment, services and applications, but it tries to present materials about possible functionalities for communication and access to information as a basis for the discussion of their possible impact on supporting people in their everyday activities. For example, considering audio/video communication, the aims of the document are not the presentation and discussion of its possible implementation, but of the possible impact that being able to communicate by voice and to transmit and receive images from everywhere and at any time could have to support people, e.g. in living independently.

The document starts with a short presentation of the situation today, where a set of evolving traditional services (telephone, radio, and television) coexists and is merging with Internet and services available on it. This also includes a short review of on-going activities about accessibility, even if accessibility is not the main interest of the document.

In Section 3, support services that are evolutions of traditional services and/or are made available or more efficient by the use of the Internet, are briefly presented, starting, as an example, with relay services. Internet applications are considered in the context of different domains. For example, social contacts, education, and applications of navigation systems are described, and some evolutions connected with the diffusion of broadband networks are discussed.

There are several limitations in what is available today. In Section 4, the argument is proposed that some of these limitations are due to the lack of innovation in the eInclusion sector. Some technology is already available, that is not sufficiently and efficiently used to improve the situation.

In Section 5, the foreseen developments of network and network services as they appear in relevant documents worldwide are summarised, including Internet itself, the Internet of Services, the Internet of Things, and the Internet of Media.

In Section 6 these developments are discussed in the frame of the emergence of the Information Society, as a form of an Ambient Intelligence environment. The main characteristics of AmI (Ambient Intelligence) are summarised, with reference to widely available European Commission documents (ISTAG, 2003).

Section 7 tries to foresee how people will live in the AmI Information Society. First, the meaning of services (as available functionalities) is clarified. Then, two simple scenarios (based on functionalities foreseen (e.g. in the ISTAG scenarios) are considered, one including a blind and a deaf student, the second an old woman living alone. These persons are observed while carrying out activities necessary for studying and living independently. The ICT functionalities to be used to carry out these activities are considered. Possible advantages and disadvantages in comparison with the situation today are pointed out, together with the possibility of using some of them to explicitly support people, if necessary.

Finally, in section 8 the discussed functionalities are summarised, pointing out whether they are considered available as part of the general specifications of the AmI environment or additional specifications need to be introduced so that the resulting functionalities are usable and supportive for people with activity limitations.

Most of the presented material has been produced in the context of the Design for All for eInclusion - DfA@eInclusion EC-funded Coordination Action. Additional information can be found in (Emiliani et al 2008) and (Emiliani et al. 2009).

2. Networks and network technology: the present situation

The aim of this section is to identify some general features of available ICT networks, systems and services, useful to carry on a discussion about the implications that the present status and the on-going developments may have on socio-economic inclusion of all citizens, including people with activity limitations, in the emerging Information Society.

2.1. A historical perspective

When the interest in the use of information technology and telecommunications by and for people with activity limitations started, the situation was relatively simple: the main service for interpersonal communication was the telephone, and information was distributed by means of radio and television. Computers were mainly stand-alone units used in closed and specialised communities (e.g. those of scientists and businessmen) (Emiliani 2009).

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

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

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

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

Today, after a period of relative stability, the developments in solid state technology and optoelectronics, which made possible the increase of the available computational power, the integration of "intelligence" in all objects, and the availability of broadband links, and, particularly, the fusion between information technology, telecommunications, and media technologies and industry, are causing a revolution in the organisation of society that is supposed to change from an industrial to an information society. Therefore, in the short term, we are experiencing the development of a complex multimedia environment (when all media are represented by numbers it is easy to them in different ways).

In the medium, long term it will cause a reorganisation of the society (emergence of the Information Society). The emergence of the Information Society is associated with radical changes in both the demand and the supply of new products and services. The changing pattern in demand is due to a number of characteristics of the customer base, including: (i) increasing number of users characterised by diverse abilities, requirements and preferences; (ii) product specialisation to cope with the increasing variety of tasks to be performed, ranging from complex information processing tasks to the control of appliances in the home environment; and (iii) increasingly diverse contexts of use (e.g., business, residential and nomadic).

2.2. Internet and the Web

The wide diffusion of mobile telephony, the introduction of digital radio and television, and interactive TV and the wide availability of multimedia digital materials are presently changing the way conventional services for interpersonal communications and access to information are implemented and used.

However, the most interesting development is the wide diffusion of the Internet network and of services running on it (mainly the World Wide Web).

2.2.1. The World Wide Web

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

Recently, in addition to its use as a as a repository of information (the Web) (if accessible - guidelines for accessibility exist - useful as such for making available a lot of relevant information to users), the Web is also used as a:

- socialising virtual environment (Web2.0, Online Collaborative Systems, Social Networks) (important as such to give people the possibility of social interaction, but offering additional opportunities);
- explicit support to people;

- repository of basic support to people with activity limitations (service computing, cloud computing) (the "Raising the floor"[1] and the "Cloud4All" projects are examples of such use).

The following constitute an attempt to outline key points, which may have an impact on eInclusion.

2.2.2. The Web: what's new in Web 2.0?

One of the most interesting phenomena regarding the web is represented by Web 2.0, also called the wisdom Web, people-centric Web, participative Web, and read/write Web (Murugesan, 2007). The term "Web 2.0" refers to changes in the ways software developers and end-users use the web and the internet *as a platform*.

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

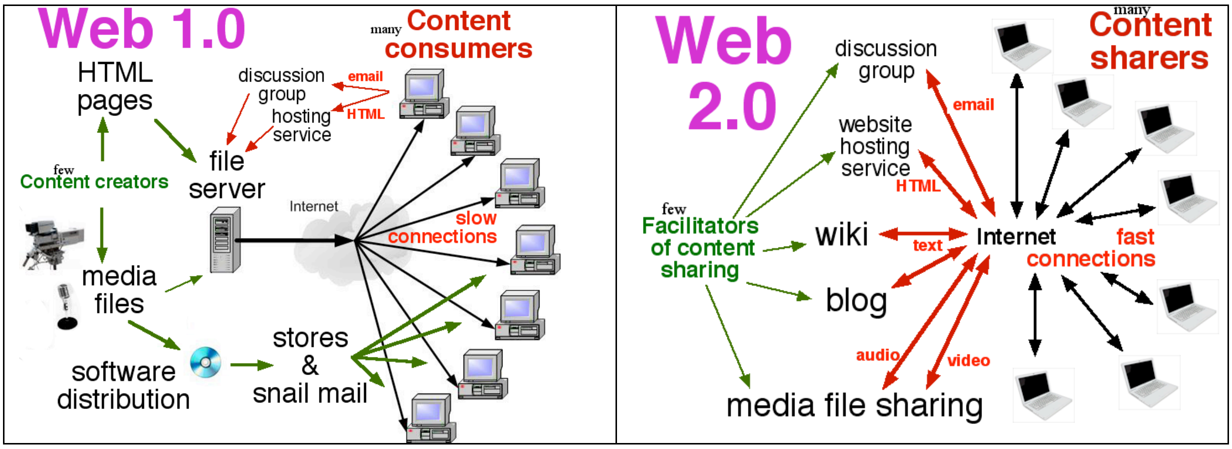

Fig. 1. Comparison between Web 1.0 and Web 2.0.

Web 2.0 websites represent more than just a searchable container for information. They can make the network e.g. a platform for computing, allowing users to run software applications entirely through a browser (as in Google Docs[2]). These sites may have an "architecture of participation" that encourages users to add value to the application as they use it. This is clearly different from what happens in traditional websites, in which visitors can only view information, while contents can only be added and modified by the site's administrator.

Common characteristics found in Web 2.0 websites are:

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

[1] http://www.raisingthefloor.org/, last visited on 2012-02-20
[2] http://docs.google.com/ , last visited on 2012-05-18

Some examples of Web 2.0 sites are:

- Google Docs, which makes the internet a platform for authoring documents and spreadsheets and allows to share them with users within a community;
- iTunes[3], mainly because of its music-store portion;
- Flickr[4] and Panoramio[5], which benefit from their shared photo-database and from its community-generated tag database;
- eBay[6], Wikipedia[7], del.icio.us[8], Skype[9], which enable sharing human connections and establishing networks through Web 2.0, growing in effectiveness the more people use them.
- YouTube[10], Facebook[11], Twitter[12].

2.3. Some interesting new technology

Some interesting technology is presently being used in the Web environment, which need attention from the perspective of Inclusion, because its use could favour/impede inclusion for people.

2.3.1. Rich Internet Applications

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

Techniques such as AJAX have evolved that have the potential to improve the user-experience in browser-based applications. AJAX is not a new technology itself; it is based on several technologies, and combines them in a new powerful ways. From a practical point of view, it allows a web-page to request an update for some part of its content, and to alter that part in the browser, without needing to refresh the whole page at the same time. This increases the responsiveness of applications and facilitates interaction of users with data stored on servers, which in Web 1.0 happened exclusively through the use of HTML forms and complete page reloads.

Common techniques used in Web 2.0 also include Adobe Flash[13] and Adobe Flex[14], which are both powerful application development solutions for creating and delivering RIAs across the web. They enable enterprises to create multimedia-rich applications that enhance user experience, changing the way people interact with the web.

2.3.2. Web Content Management Systems

[3] http://www.apple.com/it/itunes/store/music.html , last visited on 2012-05-18
[4] http://www.flickr.com/ , last visited on 2012-05-18
[5] http://www.panoramio.com/ , last visited on 2012-05-18
[6] http://www.ebay.com/ , last visited on 2012-05-18
[7] http://wikipedia.org/ , last visited on 2012-05-18
[8] http://del.icio.us/ , last visited on 2012-05-18
[9] http://www.skype.com/ , last visited on 2012-05-18
[10] http://www.youtube.com, last visited on 2012-05-18
[11] http://www.facebook.com/, last visited on 2012-05-18
[12] http://twitter.com/, last visited on 2012-05-18
[13] http://www.adobe.com/products/flash /, last visited on 2012-05-18
[14] http://www.adobe.com/products/flex/ , last visited on 2012-05-18

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

The general term WCMS embraces several kinds of software, each aimed at a different scope and specialized to fulfil different usage patterns. Some examples are wiki platforms (such as the one on which Wikipedia is built[15]), weblog platforms (such as WordPress[16]) or general purpose tools to build and maintain web sites (ranging from open source solutions such as Joomla[17], Lenya[18] or Plone[19], to high cost products such as Vignette[20] or Documentum[21]).

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

Web 3D

The Web3D Consortium[22] is a non-profit, international standards organization utilizing its broad-based industry support to develop the X3D specification for communicating 3D on the web between applications and across distributed networks and web services, with the support of ISO and W3C.

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

Semantic Web

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

The Semantic Web activities at W3C[23] provide web sites with standards allowing to publish internet contents in a form that machines can process and integrate more readily. A framework is defined that allows data to be shared and reused across application, comprising:

---

[15] http://www.mediawiki.org/wiki/MediaWiki , last visited on 2012-05-18
[16] http://wordpress.org/ , last visited on 2012-05-18
[17] http://www.joomla.org/ , last visited on 2012-05-18
[18] http://lenya.apache.org/ , last visited on 2012-05-18
[19] http://plone.org/ , last visited on 2012-05-18
[20] http://www.vignette.com/ , last visited on 2012-05-18
[21] http://software.emc.com/products/product_family/documentum_family.htm , last visited on 2012-05-18
[22] http://www.web3d.org/ , last visited on 2012-05-18

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

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

2.4. eInclusion issues

2.4.1. The accessibility of Web

Accessibility of web sites has traditionally been handled through guidelines, often embedded in national laws.

One of the most well-known organizations involved in establishing guidelines for accessibility for the web is the Web Accessibility Initiative (WAI), which is part of the World Wide Web Consortium (W3C). WAI has published in 1999 the well-known Web Content Accessibility Guidelines (WCAG) 1.0[24], which explain how to make web content accessible to people with activity limitations. In 2008, the WCAG 1.0 guidelines have been replaced with an updated version reflecting technological changes happened since 1999, the Web Content Accessibility Guidelines 2.0 (WCAG 2.0).

The WAI (WCAG 1.0) guidelines have been reworked and taken as an inspiration to publish national laws to regulate the accessibility of web sites in a number of countries. A transition toward WCAG 2.0 is now under discussion in many European countries.

Main characteristics of WCAG 2.0

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

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

[23] http://www.w3.org/2001/sw/ , last visited on 2012-05-18
[24] http://www.w3.org/TR/WAI-WEBCONTENT/ , last visited on 2012-05-18

2.4.2. Impact of Web 2.0 on eInclusion

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

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

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

2.4.3. WAI ARIA

Many Web applications developed with Ajax (also known as AJAX), DHTML, and other technologies pose additional accessibility challenges. For example, if the content of a Web page changes in response to user actions or time- or event-based updates, that new content may not be available to some people, such as people who are blind or people with cognitive disabilities who use a screen reader. WAI-ARIA addresses these accessibility challenges by defining how information about this functionality can be provided to assistive technology. With WAI-ARIA, an advanced Web application can be made accessible and usable to people with disabilities. WAI-ARIA provides a framework for adding attributes to identify features for user interaction, how they relate to each other, and their current state. WAI-ARIA describes new navigation techniques to mark regions and common Web structures as menus, primary content, secondary content, banner information, and other types of Web structures. For example, with WAI-ARIA, developers can identify regions of pages and enable keyboard users to easily move among regions, rather than having to press Tab many times.

WAI-ARIA also includes technologies to map controls, Ajax live regions, and events to accessibility application programming interfaces (APIs), including custom controls used for rich Internet applications. WAI-ARIA techniques apply to widgets such as buttons, drop-down lists, calendar functions, tree controls (for example, expandable menus), and others.

WAI-ARIA provides Web authors with the following:

- Roles to describe the type of widget presented, such as "menu," "tree item," "slider," and "progress meter"
- Roles to describe the structure of the Web page, such as headings, regions, and tables (grids)
- Properties to describe the state widgets are in, such as "checked" for a check box, or "has popup" for a menu.
- Properties to define live regions of a page that are likely to get updates (such as stock quotes), as well as an interruption policy for those updates—for example, critical updates may be presented in an alert dialog box, and incidental updates occur within the page
- Properties for drag-and-drop that describe drag sources and drop targets

- A way to provide keyboard navigation for the Web objects and events, such as those mentioned above

3. ICT applications in eInclusion

Concurrently with the effort of making ICT services and applications available (i.e. accessible) to people with activity limitations, efforts have been devoted to the use of ICT in order to set up services and applications to support people with activity limitations when they need to communicate or access information remotely. Some examples are offered in the following.

3.1. An example: the relay service

The relay service is described as an example of a classical service, where technological development may have an important impact. The telecommunications Relay Service, also known as TRS, Relay Service, or IP-Relay, is an operator service that allows people who are deaf, hard–of–hearing, speech disabled, and deaf blind to place calls to standard telephone users via TDD (Telecommunication Device for the Deaf – Text telephone), TTYs (Teletypewriter), personal computers or other assistive telephone devices.

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

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

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

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

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

Evolutions

Relay service without operator

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

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

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

3G relay services

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

3.2. Internet and the Web

The wide availability of Internet and consequently the wide diffusion of Web services (including Web 2.0) have offered the possibility of increasing the type and number of services and applications that could support the inclusion of people with activity limitations.

3.2.1. Social Contact

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

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

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

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

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

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

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

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

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

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

3.2.2. Education

Another very important set of networked information technology applications is the one connected with technology enhanced learning. Initially known as 'computer-assisted learning' and later e-Learning, the study of improving learning processes by the use of technology has evolved into the research domain known as 'Technology-Enhanced Learning'. Its objective is to encourage the emergence of new learning models that are sustained by the context-aware use of technology and anchored in the practices of users.

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

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

Educational Course Management Systems and Virtual Learning Environments

Educational Course Management Systems and Virtual Learning Environments are intended for use by institutions in Higher Education. This makes it easy for teachers to create online courses. As discussed in Wikipedia, Learning Management Systems[25] go far beyond conventional training records management and reporting. The added value for Learning Management Systems is the extensive range of complementary functionality that they offer. Learner self-service (e.g. self-registration on instructor-led training), training workflow (e.g. user notification, manager approval, waitlist management), provision of on-line learning (e.g. Computer-Based Training, Read & Understand), on-line assessment, management of Continuous Professional Education (CPE), collaborative learning (e.g. application sharing, discussion threads), and training resource management (e.g. instructors, facilities, equipment), are some of the additional dimensions of leading Learning Management Systems.

Virtual Learning Environments[26] (VLE) are software systems designed to help teachers by facilitating the management of educational courses for their students, especially by helping teachers and learners with course administration. The systems can often track the learners' progress, which can be monitored by both teachers and learners. While frequently thought of as primarily tools for distance education, they are most often used to supplement the face-to-face classroom.

[25] See http://en.wikipedia.org/wiki/Learning_Management_Systems, last visited on 18-May-12.
[26] See http://en.wikipedia.org/wiki/Virtual_learning_environment, last visited on 18-May-12.

Content development and distribution tools

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

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

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

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

Testing and quizzing tools are dedicated tools that are useful for the production of online tests, quizzes and games. They allow to create online test/quiz, edit questions and answers, and set timers. Using such tools tutors and course managers can create on-line interactive multiple choice questions quickly and easily. Some software tools enable to design and publish rich-media quizzes typing in questions in the editor and inserting pictures, sounds, videos or flash animations. Assessment reports are automatically generated.

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

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

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

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

3.2.3. Principles for accessibility in online distributed learning

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

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

Provide equivalent access to auditory and visual content based on user preference. To be fully accessible to deaf or hearing-impaired users, applications should provide equivalent access to all auditory aspects of learning technologies and content, e.g. it is necessary to caption all auditory content or to provide a text transcription of auditory content. For blind or visually impaired users, applications should provide equivalent access to all visual aspects, e.g.it is necessary to add text descriptions to all static images and to provide audio description tracks for multimedia, describing visual aspects of the content.

Provide compatibility with assistive technologies and complete keyboard access. To assure accessibility, the technology enhanced learning systems, both in their synchronous or asynchronous functioning, must be designed to support the interaction by means of assistive technology devices. In such a way, the access is guaranteed to persons using alternate interaction devices and methods. In particular a complete interaction must be guaranteed using only the keyboard.

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

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

3.3. Positioning, orientation, navigation, and localization

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

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

Positioning

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

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

Landmarks

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

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

- One is based on Bluetooth technology. When people approach a Bluetooth transmitter carrying an appropriate receiver, pre-recorded information will be read out. Bluetooth transmitters need an energy supply in the form of, for example, an integral battery.
- A second possibility is based on what is called RFIDs – Radio Frequency Identification tags.
- WLANs – Wireless Local Area Networks – local, radio-based networks - are a third possibility to send information about what is located in the vicinity to, for example, a mobile telephone or tablet.

All these systems have pros and cons for the user.

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

Orientation

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

Navigation

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

Maps

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

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

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

Another method for people with visual impairments is a verbal description where the route is explained in sequence. This information can, for example, be recorded on a pocket memory and retrieved subsequently as the user is moving along. One disadvantage is that there is no help if something goes wrong on the way. Nor is there, of course, anything that gives a warning of impediments in the form of road works and the like.

3.4. Broadband services

With the advancements in technology and the diffusion of mobile devices and broadband, it has become possible to send and receive large quantities of information via computer networks in a variety of contexts. The opportunities for communication have broadened to include e-mail, chat and video communications in real time and, thus, it has become easier to choose the means of communication that best suits each individual (Roe, 2006). The bottom line is that technological developments have made it possible to implement a series of new services for people with disabilities. For example, the National Post and Telecom Agency (Post-och telestyrelsen PTS), in Sweden, has set up trials for a number of new services intended to help people with different form of disabilities:

- Service centre for people who are blind or deaf blind: this service was developed to enable communication between blind or deaf blind person and a manned service centre, with the aid of a computer-based terminal with cameras and broadband connection. The conversation can be conducted through pictures, text and speech. This service can in principle help blind or deaf blind people to read food packaging, or to try to find something they have lost and is actually lying right under their nose.

- Distance education for people with mild aphasia. This service exploits the possibility of combining speech and pictures in distance learning, to help people mild aphasia to communicate as effectively as possible. Distance courses, offered using the best possible broadband technology available, allow students to continue living at home while they are studying.
- Digital distribution of talking books to university students. The service provides access to talking books through broadband networks for University students with reading disability (people with visual impairment, dyslexia and restricted mobility). Students can use the service to get their course literature via digital distribution.
- Broadband for people with intellectual impairment. This service offers the possibility for people with intellectual impairment to communicate with each other at a distance with two-way video communications with high audio and video quality. Using a computer with a broadband connection provides opportunities for enhanced participation and independence.
- Distance education in sign language. This service offers flexible courses allowing sign language interaction between course leaders and participants. Communication takes place by video over the Internet, either as direct communication or through the participants downloading video files or sending video messages.
- Winning Communication – distance guidance. This service uses video communication in regular work at employment offices, to allow jobseekers with disability to contact specialists at the employment offices and thereby enhance opportunities of finding work.
- Mobile video communications for people who are deaf. This service offers the opportunity to deaf people to use video calls to communicate with people using sign language. A deaf person can contact a sign language interpreter through a 3G telephone and communicate directly with a hearing person. This may be useful, for instance, for distance interpretation, when visiting the bank or during a spontaneous meeting.

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

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

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

4. The near future: on-going technological developments

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

4.1. Computing power

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

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

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

4.2. New Interfaces

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

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

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

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

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

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

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

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

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

4.3. The interconnected world

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

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

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

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

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

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

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

4.4. Services on demand

With the ability to be connected everywhere, it is possible to seek assistance at any time. A person who doesn't understand how to operate something can instantly involve a friend, colleague, or professional assistant, who can see what he or she is looking at and help. Someone who needs mobility assistance could travel independently, yet have someone available at the touch of a button. These assistants could help think something through, see how to get past an obstacle, listen for something, translate something, or provide any other type of assistance, and then "disappear" immediately. From this perspective, it is interesting to observe that technology can be used to enhance human support. This can be invaluable for the psychological welfare of people.

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

4.5. Integrated approaches

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

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

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

5. Future networks

An impressive research and development programme has been launched in Europe for the development of approaches and technologies for the deployment of future networks and services. It is interesting to see if and how these developments are in line with the migration toward living scenarios as the ones described e.g. in the ISTAG documents (ISTAG 2003).

In the relevant Commission documents[27] it is taken for granted that people will live in a Networked Future, in a world where they will be connected at any time (networks will allow people to stay permanently connected), anywhere (from personal to global environments and everything in between), to anything (all kind of objects and artefacts, and also software virtual objects).

Evolutionary improvements to the current network will up to a point help sustaining the growth of the Internet, but are not enough to face the deep rooted weaknesses of Internet with regard to mobility, scalability, wireless generalisation, broadband evolution, multiplicity of services, environments and contexts to serve, security and trust. For example, the Future Internet should be able to sustain by one or many orders of magnitude higher the number of people, devices and objects connected (billions, perhaps even hundreds of billions of users, sensors, tags, processes, micro controllers), ensure efficiency, security and trust in transactions for new services, incorporate mobility and universal connectivity in its conception, cater for various connectivity schemes, include the technical features for easy operations and management including guarantees for privacy, multiparty governance and delivery of new services.

The Internet was designed and primarily used by scientists for networking research and for exchanging information. However due to the explosion of the centralised World Wide Web (which has started as a document repository) and its successful descendants (Web 2.0 and P2P), along with the dramatic increase of net-based audio-visual material (networked media) that has been produced by professional and amateur users, the Internet is rapidly transforming to a fully-fledged virtual collaborative environment that facilitates media services, interaction and communication. Therefore the vision that the Future Internet will be an Internet of User Generated Media Content is about to be a reality soon. The vision of a Future Internet of User Generated Content poses many technological challenges. In particular, the future Internet should provide mechanisms embedded into the network to ease the personalisation, adaptation, accessibility, search and intellectual property protection of user generated content.

In this short summary the interest is not in the development of the infrastructure itself, but in the aspects that are connected to the perception and use of network facilities and services by end users.

5.1. Internet of services

The first interesting observation is that the future network is not only seen as an infrastructure for communicating and accessing information, but as a space where services are made available and can also be implemented and/or modified by end users.

The emergence of the Internet of services implies different fields of activity.

Service Front Ends

Creation of services by the end-user (Web 2.0) is the trend in the use of internet technology that aims to facilitate creativity, information sharing, and, most notably, collaboration among users. Going

[27] http://cordis.europa.eu/fp7/ict/future-networks/publications_en.html

beyond this, research into "Service Front Ends" aims to enable users to adapt, customise and control services according to their needs. People want to be in control of the applications they use and they want to mix services and data to compose services which are truly useful for them, matching their needs for that moment and in that context. An example of this composition of services and data is provided by so-called mashup technology. Empowering the user to develop their own services implies that the user should be, much more than before, at the centre of attention of developers of software tools.

In particular, a lot of interest is on serving people who are mobile and require wire-free and nomadic access via a growing number of diversified communications devices and appliances. Examples of activities carried out in this environment are:

- Development of a personal smart space that is associated with the portable devices carried by users. It contains the user's profile and preferences and functionality for exchanging information with other smart spaces. When it comes in touch with another smart space, systems and applications might be adapted to the preferences of the user and relevant information might be exchanged;
- Support for a continuous interaction with applications through a variety of interactive devices (including cell phones, tablets, desktop computers, digital television sets, and intelligent watches). People can start an application on one device and when they need to move they can continue their session on another suitable device, with the implementation of so-called migratory interactive services;
- Support to the creation with mobile devices, of instant services, that will provide useful information to other, remote users. Specific research questions to be addressed are:
    - What tools are required to allow each user with a mobile device to become a service provider?
    - How should the mobile platform behave to make it simple to use and efficient?
    - How can this type of distributed, volatile services and their associated knowledge or information be achieved?
    - And how can the business opportunities this new scenario brings about are exploited?

The software technologies that will be developed for the Future Internet put the user at the centre of attention. The researches classified in "Service Front Ends" share the aim of empowering users to do things which they can't currently do with software technology. Some of them go as far as enabling the user to develop their own services, whereas others support the user's mobility. They will also develop a methodology for developing stable and consistent user interfaces for service oriented architectures, to optimise the quality of experience for the user. Moreover, they will provide developers with methodologies and tools to develop consistent user interfaces for applications developed in a service oriented manner. Such interfaces need to provide the user with a good quality of experience, even though the basic building blocks of the application (the individual services) have been designed in a loosely coupled way.

Service Architectures

The activity is on the topics of service oriented architectures and service oriented computing. The developed approaches allow pieces of software to be made available as "services" that can be easily reused and composed into applications. The vision is that, given specific user requirements, applications can be composed from loosely coupled services. If changes occur in the environment, the application can dynamically (on the fly) recompose itself to address the new needs.

Virtualised Infrastructures

Research is aimed to efficiently manage and synchronise IT resources to match fluctuating business requirements and to enable businesses to provide optimal infrastructure service at a justifiable cost. It addresses the whole range of challenges in providing computing, storage, communication, data, and information as services. In the last 10 years, with the advent of key technologies such as grid, virtualization and web services, the idea of managing an infrastructure with the ability to share resources has moved closer to reality.

Reference Service Architecture

By means of intensive collaboration, the aim is of delivering a reference service architecture in which the results of many of the individual research results will fit. This is supposed to be one of the important outcomes of the NESSI[28], the European Technology Platform on software and services. NESSI groups more than 250 organisations from industry and academia that share a common long term strategy on software and services to contribute to Europe's competitiveness.

Service/Software Engineering

The challenges of developing good quality and reliable software and services for the Future Internet are getting bigger and bigger, as is clear from the fact that users will develop their own services, which will run on the internet and these must be accessible by millions of people. Of course this software should not have any negative side effects, which requires new research into validation and verification. Another question is how to ensure an overall quality of experience to users when an application is composed of services that are developed by somebody else and of which they know only the interface? How can people depend on these base-services?

5.2. Internet of Things

In the Internet of Things, everyday objects, rooms, and machines are connected to one another and to the larger digital world. In this environment, for example:

- Mobile phones would pay for things like subway fare or cosmetics from a Web site;
- Radio Frequency Identification (RFID) tags would be used to monitor access to VIP clubs and passes for ski lifts;
- Sensors, robotics and nanotechnologies would enable a balanced lifestyle and independent living by supporting seamless digital life recording, active stress prevention, well-being and fitness, and assisted living;
- Sensors on expensive factory equipment would tell people when the machinery is about to fail;
- Cargo shipping containers could search their contents for nuclear material or other hazards;
- Every office could report its temperature and humidity and whether its lights are on or off;
- Each foot of a geographical area's streets and highways could monitor traffic flow;
- In the home environment the fridge could talk to the microwave, the microwave to the nearby toaster, and the toaster to the stove.

Therefore, Internet of Things is not just putting Radio Frequency Identification tags on some dull thing so *smart* people know where that dull thing is. It is about embedding intelligence so things become smarter and do more than they were proposed to do.

The move from today's Internet of Machines to tomorrow's Internet of Things reflects several visible shifts:

[28] www.nessi-europe.eu

- from systems to software based services;
- from passive RFID tags to wireless sensors;
- from Web 2.0 to the Semantic Web;
- from high-technology to trusted technology;
- from features and options to experienced sense and simplicity;
- from always-on to always-responsive, and from exposure to privacy.

The Internet of Things means the fusion of the physical and digital worlds:

- Physical entities have digital counterpart;
- Objects become context-aware – they can sense, communicate and interact;
- Immediate responses can be given to physical phenomena;
- Instant information can be collected about physical entities;
- Intelligent real-time decision making becomes possible, thus opening up new opportunities to handle incidents, meet business requirements, create new services based on real-time physical world data, gain insights into complex processes and relationships, address environmental degradation (pollution, disaster, global warming), monitor human activities (work, criminal, health, military), improve infrastructure integrity (civil, energy, water, transport), and so on.

Tremendous challenges are related to the Internet of Things as reported in the already cited Commission documents[29]:

- What are the constraints that a massive deployment of things and devices at the network periphery put on network capabilities and architectures?
- How to compress a massive amount of data into discrete pieces of information in a secure timely manner through the right medium and appropriate granularity?
- Which applications will first become typical and under which business models will they operate? Will they emerge first in a professional environment (e.g. real-time enterprise) or private environment (e.g. home, lifestyle)?
- How will Internet of Things applications affect users control over their own privacy and how will they react? Which security requirements will emerge on the network infrastructure and the service infrastructure? How can privacy and security features be integrated from the early stages of system design?
- How to address the issues of naming, addressing and querying of the physical world? More specifically, how the service discovery platforms that will be needed to deploy sensor networks may impact the overall governance of the Internet of Things?
- How can the principle of 'right to silence' or 'silence of the chips' that allows individuals to disconnect from any application be integrated into the Internet of Things systems? It is also important to stress that when things are networked they become social actors. They are not of course human social actors, but they are things with social activity. Therefore, the question is: "What sort of world will people inhabit with networked social actors that are things?"

5.3. 3D and media Internet

The Internet of 3D Media will not only radically change the entertainment industry, but it is also expected to stimulate and enhance creativity, productivity and community relations in the professional sphere. User-generated/centric content as well as community networks and the use of peer-to-peer (P2P) systems are expected to generate new business opportunities. This will be made possible by:

[29] http://cordis.europa.eu/fp7/ict/future-networks/publications_en.html

- the interaction of content combined with interactive search capabilities across distributed repositories and P2P networks (also mobile);
- the dynamic adaptation to characteristics of multiple terminals.

Innovative applications such as massive multiplayer games and virtual environments accessible also on mobile devices will emerge. These environments hold the promise of a "3D Media Internet" revolution forming the basis of future networked and collaborative platforms in residential and professional domains (including creation, delivery and rendering), in virtual/gaming applications, and in digital and electronic cinema.

The evolution of "3D Media Internet" is determined by (i) an increasing participation of users (User Generated Content), (ii) by the use of new forms of media (3D Virtual Environments) and (iii) by the need to find the content people are looking for (Multimedia search).

Media experts have identified some challenges to the diffusion of 3 D environments. They are:

- lack of ‘true’ interaction between the users and the media. This problem is essentially caused by the restrictions imposed by limited network capabilities (e.g. bandwidth, time delay, latency, etc.); that preclude a full appreciation of the immersive media applications relying on the deployment of 3D virtual environments;
- lack of efficient multimedia search and retrieval mechanisms;
- the lack of truly collaborative environments and lack of ‘emotional communication’ among users and communities;
- Lack of intelligence, ability to adapt to the users’ preferences, devices and access networks.

Many technological challenges exist, as:

- mechanisms embedded into the network to ease the personalisation, adaptation, accessibility and search;
- protection and the enforcement of intellectual property rights of user generated content;
- facilitation of a smooth transition from 2D content to 3D content;
- Support for the user participation in 3D content generation and fruition within enhanced 3D collaborative environments;
- empowerment of communities for a dynamic content creation and provision;
- provision of efficient delivery mechanisms, relying on service-centric networks able to allow end-users to efficiently request, find and retrieve information regardless of its location, to transport multimodal 3D objects and support integrated multifunctional devices able to render multimodal media formats

6. The Information Society – Toward "Ambient Intelligence"

6.1. Introduction

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

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

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

This section tries to catch some aspects of this transition from the perspective of people with activity limitations.

6.2. Transition to AmI

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

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

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

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

Implementations of AmI-like approaches (that is integration of ubiquitous computing and communication with intelligent user interfaces) have already been in use for some years. Solutions based on, for instance, RF technology, Bluetooth, WLAN or global positioning systems have been used to get information or to communicate with devices in the environment. Some work has concerned the embedding of computation in every day artefacts (for example with the eGadgets projects of the IST programme (IST-2000-25240)[30] and the Smart-Its project (IST-2000-25428)[31]).

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

6.3. The technological perspective

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

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

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

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

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

[30] http://iieg.essex.ac.uk/egadgets.htm
[31] http://www.smart-its.org/

6.4. Development model

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

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

6.4.1. The network layer

In smart homes (today AmI-like living environments), the internal network may be made up of already existing cables as telephone cable and TV cable, the power supply network and additional infrastructure as computer cables and low voltage cables (home buses).

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

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

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

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

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

6.4.2. The platform layer - Sensing and Monitoring

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

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

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

Particular important are the following issues:

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

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

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

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

6.4.3. The user layer

The personal communicator

In all ISTAG scenarios (ISTAG 2003), where some AmI features are represented, people are equipped with a personal communicator, which is the communication system connecting the individual users with the environment. A first version of a personal communicator with many of the functions needed for interacting with an AmI like environment is possible with the integration of available technology.

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

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

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

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

User interaction

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

Intelligent interfaces are supposed to be able to adapt to the user physical, sensorial and cognitive capabilities, some of which may be restricted due to aging or impairments and/or may change along the day, due e.g. fatigue, and changes in motivation. To this end, the interface must have a model of the users and be able to make assumptions about their actual situation from the current value of a number of parameters as measured by sensors and/or made available by the evolving interaction behaviour. However, adaptive intelligent interfaces can also have problems; the most important one is the possibility of errors in adaptation, for example due to incomplete information about users or change of abilities due, e.g, to fatigue.

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

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

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

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

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

and in assisting way (e.g. by analysing and extracting the user's path patterns outside the house, the system could make suggestions and issue reminders).

6.4.4. The control layer - Intelligence in the environment

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

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

6.5. Impact on users with activity limitations: preliminary considerations

It is useful to briefly comment on some of the technologies that are anticipated to emerge as components of the AmI paradigm, and their integration in systems and services from the perspective of users with activity limitations and in relation to assistive technology. The aim of this discussion is to provide hints on the possible smooth transition from the present situation and AmI-like environments. As a matter of fact 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.

One of the main prerequisites of the intelligent environment is that interactions must be multimodal and alternative input-output systems must be available. In principle, the different modalities can be used concurrently so as to increase the quantity of information made available or, alternatively, to present the same information in different contexts, or, redundantly, to address different interaction channels, both to reinforce a particular piece of information or to cater for the different abilities of users. Obviously any redundancy in the presentation of information can be important for people who do not have available one of more sensorial channel.

Moreover, research on multimodality can concur to the development of technology of interest for people with sensorial limitations. *Voice synthesis and recognition* can be considered as an example. For recognition, the goal set in AmI is the recognition of connected speech in noisy environments. This can obviously be very important in producing efficient inputs for people who cannot use keyboards or object manipulation techniques due to activity or contextual limitations. Correspondingly, voice synthesis is anticipated not only to achieve better quality, but also to incorporate personal characteristics. 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 becoming standard in many pieces of equipment and services. This will solve the problem of tracing people who risk being lost in open spaces, and will help in navigation (e.g., for people who cannot see). However, for this second application, GPS precision should be improved. This, for example, can be obtained in closed spaces where in any case the GPS system cannot be used. GPS localisation should be integrated by the deployment of networks of sensors (Estrin, 2002; Lorincz, 2004), e.g. based on ultrasound beacons, floor sensors to determine the positions and movements of individuals, weight sensors, worn badges that emit IR pulses, and smart tags to identify objects.

Smart tags are another important technology necessary for the development of an intelligent environment. They can signal the presence of objects in the environment, and can provide detailed information about the objects to which they are attached. For example, they can be used to give information about what is contained in the refrigerator, and to allow the production of the list of goods to be bought in the supermarket, which is directly transmitted by the refrigerator itself. This technology could have a number of very important applications for people with activity limitations. A person who cannot see, equipped with a simple radio transducer could be directly informed about the items on the shelves of a supermarket. For each object, s/he could have information about weight, expiring date, composition, and so on. At home, the same person could be able to locate all kinds of small objects, for example a box of pills or spectacles, and when necessary, have information about the medicament and the dosage. The pill box could also be authorised to make the person aware of its presence, if s/he tends to forget about medication. The tags on objects in the house could be used as a means to help older people or people with memory problems by making available, when necessary, information concerning their presence and use.

Gesture recognition (Geer, 2004) is an additional important component of a new generation of systems for people with activity limitations. It can be used both to implement virtual keyboards on any surface and virtual pointing devices, and to produce interfaces for the manipulation of objects on the screen, as it is now possible with computer games.

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. This technology - with obvious problems of privacy and control for the user - is very promising in different situations. People who cannot see can be supported by agents able to access visual information for them and to “transduce” information produced by them into visual form for sighted people. The same is true for people who cannot hear regarding accessing and producing auditory information. An intelligent agent could also take care of helping people with cognitive difficulties due to impairment or age in acquiring information from the environment, and could anticipate their needs for communication and environmental control.

Lastly, a common requirement of new technology is *miniaturisation*. Many technologies are conceived as hand-held or wearable, taking also advantage of the fact that intelligence can be embedded in the environment in order to support the individual personal system. This means being light-weight, which can be important for some people and in some environments, but also availability. It is taken for granted that people can have with them everything necessary for performing even complex tasks.

From the above, some conclusions can be drawn about general characteristics of systems and services in the intelligent environment. Systems and services are nomadic, that is, they follow people. The basic system for accessing communication or information is personal (a personal communicator). It is simply a portable link with the infrastructure where the intelligence resides. It is small, wearable, and also implantable, as well as personalisable as much as is it necessary. Consequently, digital services are ubiquitous in the environment, wherever and whenever people need them, and there is no need to look for terminals, as terminals are always with people. Additionally, the infrastructure can help people to navigate and find objects in the environment (for example, medications, etc).

7. People in the Information Society

7.1. The ambient intelligence environment

In the present document, the intelligent environment is assumed to develop according to the two components foreseen in the definition of eInclusion in the RIGA Ministerial declaration[32], i.e., making available an accessible ICT environment where intelligent objects offer (support) functionalities (Fig. 2) useful for access to information, interpersonal communications and environmental control. Moreover the environment is assumed to be connected with a control centre and with the external world to contribute with more complex functionalities (made available through services).

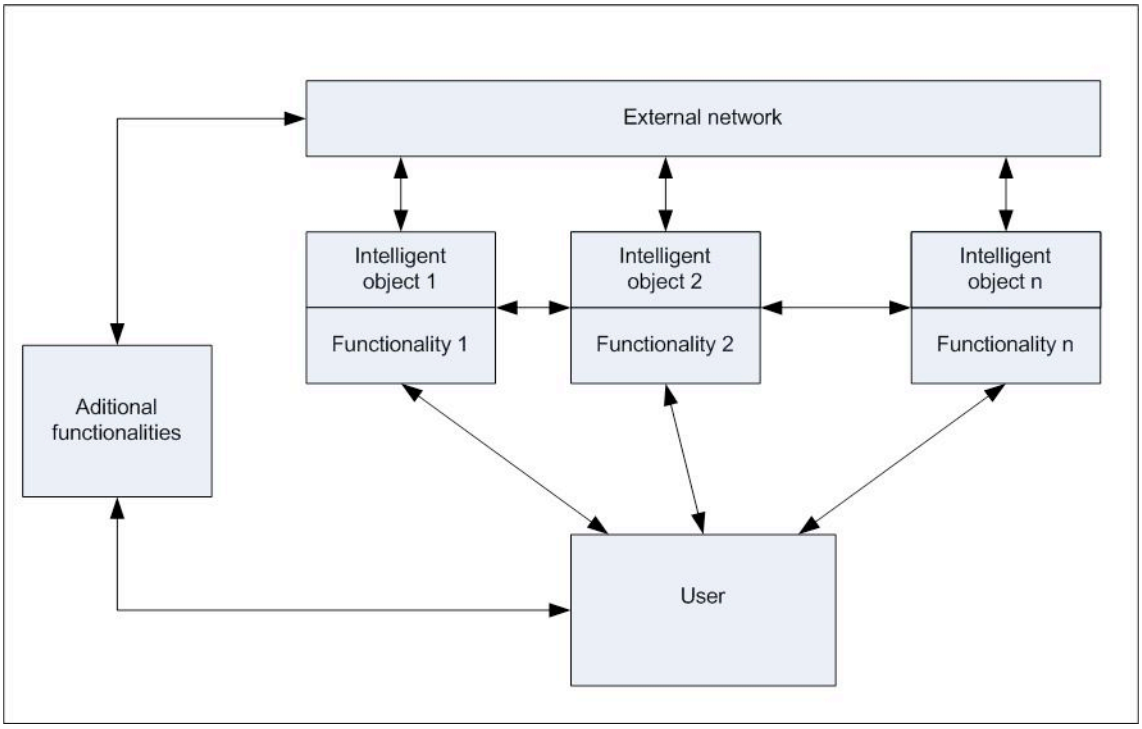

Fig. 7 - Intelligent objects and functionalities in the environment

From the perspective of interaction, a migration is foreseen from a model where the user interacts with a computer or a terminal, to a model where the user interacts using (disembodied) natural interfaces with functionalities made available by single intelligent objects, by their cooperation under the supervision of a control centre, and by the cooperation through external networks, as depicted in Fig. 3.

According to the definition of e-Inclusion in the Riga Declaration, e-Inclusion will be favoured by this emerging environment, if the functionalities made available will be inclusive (i.e., accessible) and if they will take care of supporting users with activity limitation, by redefining activities so that they can be carried out with the available abilities, and/or by proactively supporting users in tasks where they have limitations. As an example, the case of a low vision person can be considered. She can be supported with a telephone with large keys (AT solutions), but she can also be given the possibility of using a completely disembodied communication functionality (for example controlled by voice),

---

[32] e-Inclusion" means both inclusive ICT and the use of ICT to achieve wider inclusion objectives. http://ec.europa.eu/information_society/events/ict_riga_2006/doc/declaration_riga.pdf

which she can use without reaching the telephone or using a keyboard (i.e., without using her visual ability).

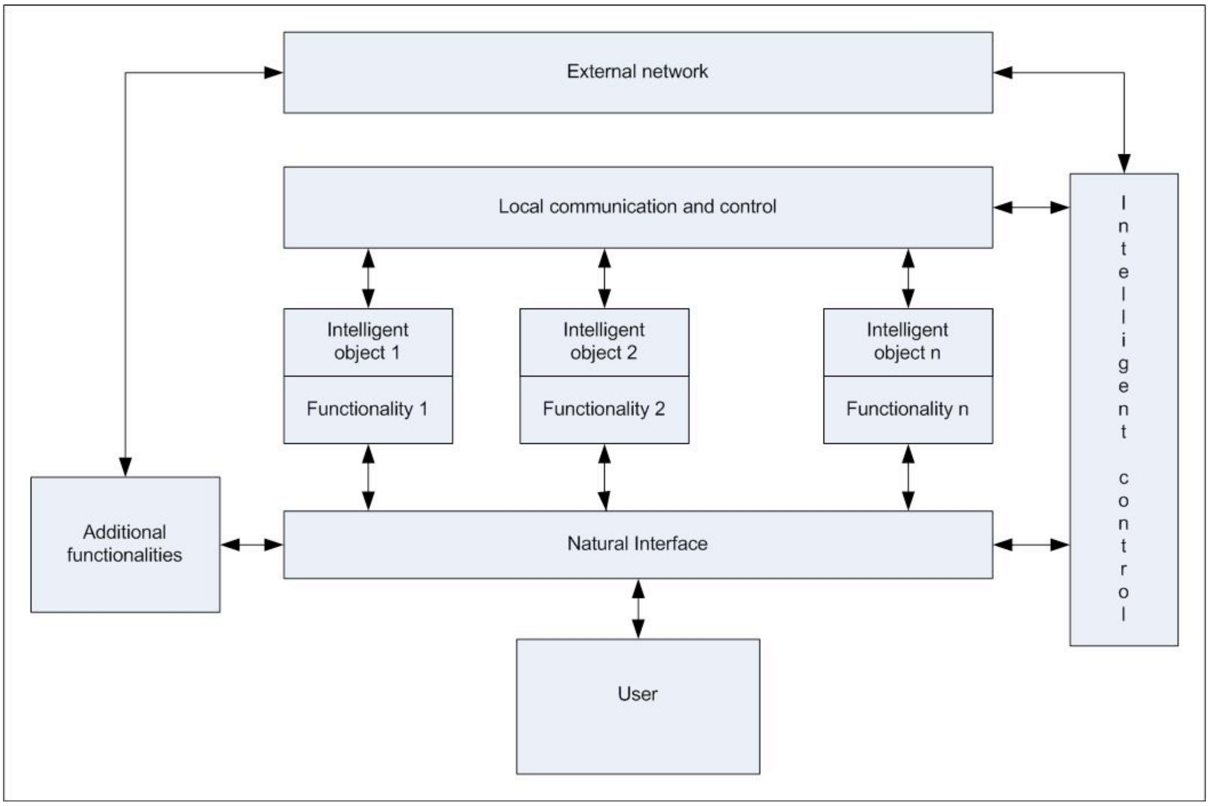

Fig. 3 - AmI environment

This is also compatible with the WHO International Classification of Functioning, Disability and Health (ICF) model (see World Health Organisation, 2001)[33], which starts with the definition of "activities" to be carried out in the environment and characterizes disabilities as limitations in performing the necessary activities, due to personal limitations and contextual factors. Therefore, people can be supported by augmenting their capabilities or acting on the context (e.g. redefining how an activity can be carried out and supporting people with activity limitations with functionalities in the environment). The approach is schematised in Fig. 4.

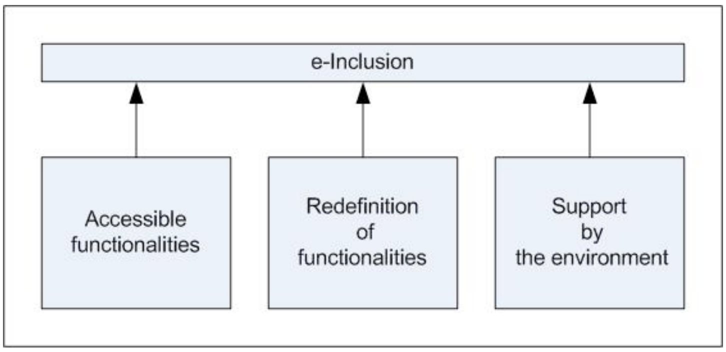

Fig. 4 – Approaches toward eInclusion

[33] WHO ICF, available online at: http://www.who.int/classifications/icf/wha-en.pdf

7.2. AmI Scenarios

Starting from functionalities foreseen in the ISTAG documents two simple scenarios are presented in order to grasp how services available in the information society could favour or impede the inclusion of people with activity limitations in the emerging information society. The scenarios do not pretend to be complete or rigorous as the ISTAG scenarios. They only summarise life situations useful for a discussion from the perspective of people with activity limitations.

The analysis of services and functionalities made available by them is not exhaustive. It only exemplifies some of the existing and foreseen possibilities. Moreover, necessary functionalities can be made available by different services. However, according to available documents, all functionalities cited in the scenarios are supposed to be available as an integral part of the AmI environment under development.

In the scenarios it is assumed that Mary (Jane) lives in a possible instantiation of the Information Society, which has evolved as an “Ambient Intelligent (AmI)” environment. The environment is accessible. Audio (e.g. speech synthesis and recognition), video (e.g. gesture recognition) and tactile (able to present information in a tactile form or to react to tactile input) interfaces are freely available in the environment. Special interfaces are supposed to be easily connected to the environment, when necessary.

Mary (Jane) is always connected through her personal communicator (P-Com) and the related set of intelligent agents, which are able to grant connection to the environment itself and to all its facilities. Its characteristics and interfaces are not precisely defined, but it can in principle make available all the necessary interaction technologies in order to adapt the environment to the type of interaction suitable for the user and the context of use. 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. Mary (Jane) may wear it as a bracelet, it may be embedded in her clothes but it may also be implantable. It is adaptive, and learns from Mary’s (Jane’s) 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. It deals with calls. When necessary, it becomes an avatar-like system and deals with most of her social communication, using her own voice. 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 it must not necessarily be a highly sophisticated piece of equipment, the performances of which may be limited by size, weight, and power. The interaction peripherals and the intelligence needed to support, for example, the transduction of information necessary to address the different modalities and to support the user can be in the environment and in the network. In principle, the only limiting factor can be bandwidth.

7.2.1. Scenario 1 – Mary - the student[34]

Scenario		
Script – Blind Mary	Script – Deaf Mary	Services
Control and interaction with the environment		
In the kitchen		

[34] The analysis does not pretend to be exhaustive, but a basis for discussion.

When Mary wakes up in the morning the rooms of her apartment adopt her 'personality' as she enters.		AmI service(s): intelligent control of the environment Functionalities: User modelling (AmI knows its inhabitants, and their characteristics and customs)
The room temperature is adjusted and a range of music choices are spoken or displayed on a Braille display. However, it is time for the morning news. Since Maria wants to be informed of what happens in the world, the radio is switched on. Using voice commands she can command a bath and switch on the gas under the coffee machine and the milk kettle. When the milk is warm (according to her liking) the gas under the milk is switched off.	The room temperature and default lighting are adjusted and a range of video choices are displayed on the video wall. However, it is time for the morning news. Since Maria wants to be informed of what happens in the world, the subtitled video transmission is switched on. Using voice commands she can command a bath, switch on the gas under the coffee machine and the milk kettle, and adjust the light level. When the milk is warm (according to her liking) the gas under the milk is switched off.	AmI service(s): intelligent control of the house; environmental control services; broadband communication facilities; alarm and support/control services. Functionalities: user modelling; speech interaction; safety control; multimedia communication. If necessary, Mary can use the P-Com, whose interface is adapted to her capabilities (sensorial, motor and cognitive) with suitable peripherals and can be programmed to mimic any remote control or (probably) a future standardised remote control.
At the end of the news, the radio tunes on the classical music station normally listened to by Maria. But this morning, Maria must do some shopping and the radio is switched off. She needs her foldable Braille display. Where did she leave it last night?	At the end of the news, the radio tunes on the video channel normally looked at by Maria. But this morning, Maria must do some shopping and the video is switched off. She needs her glasses. Where did she leave them last night?	AmI service(s): intelligent control of the house; environmental control services; relay service (automatic transduction/translation of information). Functionalities: identification of (tagged) objects; automatic transduction from text to speech (for blind Mary) or speech to text (for deaf Mary) or other modalities, if necessary.
Fortunately, the object has an intelligent tag. It is only necessary to ask the apartment to localize it.		
Shopping		
While taking her breakfast coffee Mary checks whether she has everything it is necessary for today learning. All goods on and in her desk are smart tagged.		AmI service(s): intelligent control of the house Functionalities: control of a list of (tagged) objects
Mary can remotely check if she has the musical scores she is supposed to play during the day. She is notified of the missing materials by voice or on her Braille display. Her personal	Mary can remotely check if she has the painting and engraving materials she is supposed to use today. She is notified of the missing materials on the screen of the e-fridge. Her personal	AmI service(s): intelligent control of the house; relay services; agent-based information, communication and negotiation services; broadband communication facilities; e-shopping services; multimedia interpersonal communication services.

<table>
<tr><td>intelligent agent starts to explore the network to find out who has the necessary materials, negotiating price and delivery. Musical scores, if available, can be delivered though the network and printed at home.</td><td>intelligent agent starts to explore the network to find out who has the necessary materials, negotiating price and delivery. Painting and engraving materials must be delivered at home or near home. The agent knows the brand(s) of the materials preferred by Mary, but today there is a special offer. It decides to contact her. Audio and visual communication is established with the shop. She can inspect personally the materials, also using a tactile display to check the texture of the materials to be used for the bas-relief she is presently producing, control the colours and discuss with the shop attendant about the characteristics of the offered items. Before deciding, the agent explores reference sites for comments. They are favourable. Therefore the order is confirmed and the agent asks for the material to be delivered to the closest distribution point in her neighbourhood.</td><td>Functionalities: intelligent agent for e-shopping (the agent can be delegated to take care of the shopping or it acts as an intermediary with the shop or services related to shopping – e.g. recommender services); user modelling; multimedia communication; multimedia transmission of information on tags on the goods; audio or textual description of goods; visual and/or tactile acquisition of information about goods.</td></tr>
<tr><td colspan="2">During the day Mary can check the progress of her virtual shopping expedition, using her P-Com or from any enabled device at home, the learning environment or from a kiosk in the street.

In the meantime her fridge, on the basis of its contents and the average consumption of food, suggests her what is probably lacking. She confirms the suggestions and asks the fridge to negotiate its delivery with the market. She also authorises the e-fridge to pay up to a limit of € 50. If the cost is higher, the fridge is given the task of selecting the most urgent items or reducing quantities, on the basis of Mary's usage statistics.</td><td>AmI service(s): intelligent control of the environment; agent-based information, communication and negotiation services; multimedia (interpersonal) communication services; e-shopping services.

Functionalities: user modelling; identification of (tagged) objects; intelligent agent for e-shopping (the agent is delegated to take care of the shopping and of the financial transactions an intermediary with the shop or services related to shopping – e.g. recommender services); financial transactions</td></tr>
<tr><td colspan="2"></td><td></td></tr>
<tr><td colspan="2">Learning and communicating</td><td></td></tr>
</table>

<table>
<tr><td colspan="2">The “social learning environment”</td><td></td></tr>
<tr><td colspan="2">Mary moves to her next door learning environment where a plenary meeting of a studies group in a local ‘Ambient for Social Learning’ is taking place.
The group ranges from 10 to 75 years old. They share a common desire to learn music (art) and how to express themselves with music (art).
It is led by a mentor whose role it is to guide and facilitate the group’s operation. It is not necessary that the mentor is an expert of the field, but only able to cope with the “social” aspects of the meeting.</td><td>Services(s): intelligent control of the learning environment.

Functionalities: user identification; user modelling.</td></tr>
<tr><td colspan="2">The plenary takes place in a room looking much like a hotel foyer with comfortable furniture pleasantly arranged. The meeting is open from 7.00-23.00 hours. Most participants are there for 4-6 hours. A large group arrives around 9.30 a.m. Some are scheduled to work together in real time and space and thus were requested to be present together (the ambient accesses their agendas to do the scheduling).</td><td>Service(s): intelligent control of the learning environment; eLearning services.

Functionalities: user identification; user modelling; control of (virtual) space (optimisation of each working place for the individual user or a group of users with different capabilities); optimization of the time schedule of activity (e.g. time of availability, level of expertise, and learning capabilities).</td></tr>
<tr><td>When Mary enters the room and finds herself a place to work, she hears a familiar voice asking “Hello Mary, I got the assignment you did last night from home: are you satisfied with the results?”

Mary answers that she was in general happy with her performance but there is a passage in the second movement where she is not sure.</td><td>When Mary enters the room and finds herself a place to work, she gets a tactile alarm and a message appears on a nearby display asking “Hello Mary, I got the assignment you did last night from home: are you satisfied with the results?”

Mary answers that she was in general happy with the landscape of the bas-relief but the human figure is not satisfactory. It does not have movement. It does not give the idea of a human body but of an object without life.</td><td>Service(s): navigation services; multimedia interpersonal communication services (face to face interpersonal communication with the mentor); relay services.

Functionalities: user modelling; user identification; guidance in the environment; automatic transduction of information.</td></tr>
<tr><td colspan="2">Mary is an active and advanced student so the ambient says it might be useful if Mary spends some time today trying to pin down the problem.</td><td rowspan="2">Service(s): intelligent control of the virtual space; environmental control services; agent-based information, communication and negotiation services.

Functionalities: multimedia and multimodal interaction; signal and image processing facilities in the environment, reasoning (intelligent agents) about signal and image</td></tr>
<tr><td>The enhanced interactive sound simulation and playing facilities can help her learning to play the difficult music passage, first reproducing and analysing the details of the performances of famous</td><td>The enhanced 3-D interactive image processing and projection facilities can help in trying different approximations of the figure in the landscape and in playing with different colour</td></tr>
</table>

performers and then simulating a personal performance, to be reproduced with a synthesised instrument.	combinations.	contents.
The ambient goes briefly through its understanding of Mary's availability and preferences for the day's work. Finally, Mary agrees on her work programme for the day		Service(s): eLearning services; agent-based information, communication and negotiation services. Functionalities: user modelling (abilities of the participants); intelligent agents for "understanding" availability and preferences.
One long conversation takes place with Solomon who has just moved to the area and joined the group. The ambient establishes Solomon's identity; asks Solomon for the name of an ambient that 'knows' Solomon; gets permission from Solomon to acquire information about Solomon's background and experience. The ambient then suggests Solomon to join the meeting and to introduce himself to the group.		Service(s): multimedia interpersonal communication services (face to face interpersonal communication); agent-based information, communication and negotiation services; relay services. Functionalities: user modelling; user identification; automatic transduction of information.
In these private conversations the mental states of the group are synchronised with the ambient, individual and collective work plans are agreed. In some cases the assistance of the mentor is requested. A plenary meeting begins with those who are present		Service(s): intelligent control of the environment; agent-based information, communication and negotiation services. Functionalities: user identification; user modelling (personality of the individuals in the group); control of (virtual) space; emotion monitoring; reasoning about emotions and behaviours in the continuously changing situation of the group.
Mary gives a performance of her assignment. A group member asks questions about one of Mary's decisions and alternative performances are listened to.	Mary shows the bas-relief she has produced. A group member asks questions about one of Mary's decisions and alternative 3-D visualisations are produced.	Service(s): intelligent control of the environment; multimedia interpersonal communication services; relay services. Functionalities: user modelling; user identification; automatic transduction of information.
During the presentation the mentor is feeding observations and questions to the ambient, together with William, an expert who was asked to join the meeting. William, although several thousand miles away, joins to make comments and answer some questions. The main problem is that William speaks only Finnish and therefore the conversation must be translated in real time. Automatic language translation is a common practice, as translation from text to voice and from voice to text, or lip movement, or sign language. The session ends with a discussion of how Mary's work contributes to that of the others and the		Service(s): intelligent control of the environment; broadband communication facilities; multimedia interpersonal communication services; relay services. Functionalities: transduction of information; automatic language translation.

proposal of schedules for the remainder of the day. The ambient suggests a schedule involving both shared and individual sessions.			
During the day individuals and sub-groups locate in appropriate spaces in the ambient to pursue appropriate learning experiences at a pace that suits them. Virtual private spaces are created for the individual groups. The ambient negotiates its degree of participation in these experiences with the aid of the mentor		Service(s): intelligent control of the environment; environmental control services; agent-based information, communication and negotiation services. Functionality: virtual private spaces; negotiation of participation.
The ambient and the mentor will spend some time negotiating shared experiences with other ambients – for example mounting a single musical concert with players from two or more distant sites.	The ambient and the mentor will spend some time negotiating shared experiences with other ambients – for example mounting an exposition with items in different sites, with fruition using a virtual reality system.	Service(s): intelligent control of the environment; agent-based information, communication and negotiation services; multimedia interpersonal communication services; environmental control services; relay services. Functionalities; user modelling; transductions of information; virtual reality.
They will also deal with requests for references / profiles of individuals. Time spent in the ambient ends by negotiating a homework assignment with each individual, but only after they have been informed about what the ambient expects to happen for the rest of the day and making appointments for next day or next time.		Service(s): intelligent control of the environment; eLearning services. Functionalities: user modelling; adaptation of learning materials.
Unconscious Communication		
Mary is proud of 'being in communication with mankind': as are many of her friends. Her P-Com is able to act as a voice activated 'gateway' or digital avatar of herself, familiarly known as 'D-Me' or 'Digital Me'. A D-Me is both a learning device, learning about Mary from his interactions with her environment, and an acting device offering communication, processing and decision-making functionality. Mary has partly 'programmed' it herself, at a very initial stage. At the time, she thought she would 'upgrade' this initial data periodically. But she didn't. She feels quite confident with his D-Me and relies upon its 'intelligent' reactions. She doesn't want to be bothered during her learning. Nevertheless, all the time her D-Me is receiving and dealing with incoming calls and emails. For example, Mary's D-Me has caught a message from a person D-Me, located in the nearby metro station. This person has left home without her medicine and would feel at ease knowing where and how to access similar drugs in an easy way. She has addressed his query in natural speech to Mary's D-Me, who appears to be nearby. Mary happens to suffer from		Service(s): intelligent control of the environment; multimedia interpersonal communication services; agent-based information, communication and negotiation services; relay services. Functionalities: user modelling; problem solving by reasoning by an intelligent agent; automatic transduction of information.

similar heart problems and uses the same drugs. Mary's D-Me processes the available data as to offer information. It 'decides' neither to reveal Mary's identity (privacy level), nor to offer Mary's direct help (lack of availability), but to list the closest drug shops, the alternative drugs, and to offer a potential contact with the self-help group. This information is shared with the person's D-Me, not with the person herself as to avoid useless information overload.	
Communication becomes conscious	
The above communication scheme is tenable only when "service" information needs to be exchanged, i.e. neutral information that does not imply any personal involvement of Mary. The D-Me must know what persons she must listen to with particular attention and be able to spot emotions (emotional information processing) that deserve special attention. At 11:10 a.m., following many other calls of secondary importance – answered formally but smoothly in corresponding languages by Mary's D-Me with a nice reproduction of Mary's voice and typical accent, a call from her mother is further analysed by his D-Me. In a first attempt, Mary's 'avatar-like' voice runs a brief conversation with her mother, with the intention of negotiating a delay while explaining her current environment. Finally, her mother's call is now interpreted by the D-Me as sufficiently pressing to mobilise Mary. It 'rings' her using a pre-arranged call tone and Mary can take up the call.	Service(s): agent-based information, communication and negotiation services; multimedia interpersonal communication services, relay services. Functionalities: user modelling; problem solving by reasoning by an intelligent agent; automatic transduction of information.
Informal cooperation	
Going home, Mary arrives at the local distribution node (actually her neighbourhood corner shop) where she picks up her goods. The shop has already closed but the goods await Mary in a smart delivery box. By getting them out, the system registers payment, and deletes the items from her shopping list. The list is complete. At home, her smart fridge screen will be blank. Back home, Mary goes through the work done during the morning.	Service(s): intelligent control of the environment; agent-based information, communication and negotiation services. Functionalities: user identification; financial transactions.

She is happy enough of the improvements. The execution is now technically good (even if she must learn to reproduce it with the real instrument, but she feels that it is still without life. She knows that there is a concert in the evening, where the musical composition will be performed. She decides to go. Live performances are normally more involving than recorded ones. Then, she can meet a lot of friends there, with whom she can discuss. What about having a chat with Jane? She is confident of her appreciation of the problem both from the technical and the aesthetical perspective. She calls Jane with the video-telephone. One of the walls of her living room becomes a video display. (Even if Mary is blind, the video-telephone is useful when she has friends with her). Jane asks Mary about her morning work and the improvements in comparison with the day before. They listen together to the performance synthesised by Mary on the audio facility of the classroom. Jane agrees on the improvements and thinks that it is a good idea to go to the concert and discuss with friends.	She is happy enough of the improvements. The human figure has improved, but she is not completely satisfied with some details. She has problems with colours too. There is an exposition in the modern art museum, where she can probably get some additional hints. 3-D virtual presentations are very good now, but real artefacts are still better. Then, she can meet a lot of friends there, with whom she can discuss. What about to have a chat with Jane? She is confident of her appreciation of the problem both from the technical and the esthetical perspective. She call Jane with the video-telephone. One of walls of the living room becomes a video display. Jane asks Mary about her morning work and the improvements in comparison with the day before. They reproduce the outcome of the work in the morning on the home 3-D representation system. Jane agrees that there are improvements, but probably this is not enough. They agree that it is a good idea to go to the museum to look at real artefacts and to discuss with friends.	Service(s): Intelligent control of the environment; multimedia interpersonal communication services; multimedia interpersonal communication services; broadband facilities; relay services. Functionalities: automatic media transduction; virtual reality.

However, Jane knows that a friend of their (Paul) has recorded recently the same musical composition. The intelligent agent has only suggested famous performances. Listening to the performer of the same school and with similar experience could be useful to find a satisfactory compromise. Is Mary really sure to be able to reproduce with her instrument what she has simulated on the synthesiser? Mary and Jane switch on their virtual reality facility. Now, they are sitting together in the virtual conservatory room, listening to the execution of their friend. They can replay the single parts and discuss. They can play with the computerised music synthesiser and with their real instruments. It is a fortunate coincidence that Paul is available and can join them in the virtual space.	However, does Mary know that an exposition has opened today in Japan, dealing with the same technique Mary is using for her work? Would not it be interesting to visit it together? After negotiations of their intelligent agents with the museum agent in Japan, they can stroll virtually through the museum. They can look at the exposed items and they can also touch them, because the tactile displays in their room reproduce the real tactile sensations. They could also speak with people there, if they would be able to speak Japanese. Obviously, they could also use an automatic translation service, but these services are still very expensive	Service(s): intelligent control of the environment; agent-based information, communication and negotiation services; broadband communication facilities; multimedia interpersonal communication services; environmental control services; relay services. Functionalities: automatic media transduction; language translation; agent based negotiation; virtual reality.
Moving through the city		
Planning		
Now Mary needs to plan her travel to the city. She needs to leave in 40 minutes, in order to have time should something go wrong with the traffic in the city. She asks the AmI, by means of a voice command, to find a vehicle to share with somebody on her route. The AmI starts searching the trip database and, after checking for willingness of drivers, finds someone that will pass by in thirty minutes. The in vehicle biosensor has recognised that this driver is a non-smoker – one of Mary requirements for trip sharing. From that moment on, Mary and her driver are in permanent contact if wanted (e.g. to allow the driver to alert Mary if he/she will be late). Both wear their P-Coms allowing seamless and intuitive contacts.		Services(s): intelligent control of the environment; multimedia interpersonal communication services; relay services; alarm and support/control services (city transportation service) Functionalities: user modelling; media transduction; control of car sharing.

<table>
<tr><td colspan="2">Going around</td><td></td></tr>
<tr><td colspan="2">Thirty minutes later Mary goes downstairs onto the street, as her driver arrives. When Mary gets into the car, the VAN system (Vehicle Area Network) registers her and by doing that she sanctions the payment systems to start counting. A micro-payment system will automatically transfer the amount into the e-purse of the driver when she gets out of the car</td><td>Service(s): multimedia interpersonal communication services; relay services; alarm and support/control services (city transportation service); e-shopping.

Functionalities: user identification; transduction of information; financial transactions.</td></tr>
<tr><td colspan="2">On the way to the city the shared car system senses a bike on a dedicated lane approaching an intersection on their route. The driver is alerted and the system anyway gives preference to bikes, so a potential accident is avoided. A persistent high-pressure belt above the city for the last ten days has given fine weather but rising atmospheric pollutants. It is rush hour and the traffic density has caused pollution levels to rise above a control threshold. The city-wide engine control systems automatically lower the maximum speeds (for all motorised vehicles) and when the car enters a specific urban ring toll will be deducted via the Automatic Debiting System (ADS).</td><td>Services (s): intelligent control of the environment; alarm and support/control services.

Functionalities: control of city transportation service; city traffic control and navigation.</td></tr>
<tr><td colspan="2">In the car, the dynamic route guidance system warns the driver of long traffic jams up ahead due to an accident. The system dynamically calculates alternatives together with trip times. One suggestion is to leave the car at a nearby ‘park and ride’ metro stop. Mary and her driver park the car and continue the journey by metro. On leaving the car, Mary’s payment is deducted according to duration and distance.</td><td>Services(s):): intelligent control of the environment; alarm and support/control services; e-shopping.

City traffic control; navigation services;, financial transactions.</td></tr>
<tr><td colspan="2">Out of the metro station and whilst walking a few minutes to the place, Mary is alerted by her P-Com that a Chardonnay wine that she has previously identified as a preferred choice is on promotion. She adds it to her shopping order and also sets up her homeward journey with her P-Com. Mary arrives on time</td><td>Service(s): intelligent control of the environment, e-shopping.

Functionalities: (Adaptive) user modelling.</td></tr>
<tr><td colspan="2"></td><td></td></tr>
<tr><td colspan="2">Leisure activities</td><td></td></tr>
<tr><td colspan="2">Moving around</td><td></td></tr>
<tr><td colspan="2">Mary passes through the hall. She does not need to stop at the cloakroom. She has only a small bag. She does not need any more all the equipment that students used to have (laptop PC, mobile phone, electronic organisers etc.). Her computing system is reduced to one highly personalised communications device, her ‘P–Com’ that, for example, she wears on her wrist.</td><td>Service(s): intelligent control of the environment (theatre).

Functionalities: use modelling; user identification.</td></tr>
<tr><td>Being blind, she may have a foldable tactile display for</td><td>Visual information, if she is deaf, can be reproduced on</td><td>Service(s): multimedia interpersonal communication services; relay services.</td></tr>
</table>

presentation of Braille and other tactile information.	the display of her P-Com or, alternatively, in the projection system built in her spectacles.	Functionalities: media transduction.
Tickets have been arranged by the intelligent agent and entrance is granted through conversation between her agent and the entrance control agent of the place. If she likes, the agent will make available to the AmI a description of Maria's physical and sensory characteristics. In this case a special support can be offered. In most cases she can cope with the normal facilities of the place.		Service(s): intelligent control of the environment; agent-based information, communication and negotiation services; alarm and support/control services. Functionalities: user identification; user modelling; special personal support.
The program is made available on the P-Com. AmI is tracking the position of all the people and the P-Com take care of guiding them to their seats.	The museum catalogue is made available on the P-Com. Maria's agent will take care of asking her whether she wants to buy it. In this case it will not be cancelled from the P-Com at the end of the visit. A special fare will be charged if she also wants to print it when at home or to have it mailed home in printed form. AmI is tracking the position of all the people and P-Com take care of guiding them through the exposition according to the known or explicitly expressed preferences of the persons.	Service(s): intelligent control of the environment; broadband communication facilities; navigation services; relay services. Functionalities: user identification; user modelling; transduction of information; guiding facilities.
Enjoying the concert	***Enjoying the visit***	
Now Maria is waiting for the starting of the performance. She is a musician, and she likes to follow the performance reading the musical score. She has the score available, but she asks to the concert house, just in case they would use some revised version of the musical score she has. If this is the case, the concert house will make it available to her for free, because she is a music student. Evidence of being a student is given by the P-Com. She has also time to go on the network through information about the performer and the	Now, Maria starts her visit of the museum. She does not have time to see the entire exposition. The P-Com knows what she wants to see and, in cooperation with the tacking system of the museum, is able to guide her to the sites of interest. While she is walking through the rooms, the AmI gives her some information about what is around. The quantity of information is a function of the movement speed. When she stops in front of an artefact, the AmI gives her a description of what she is looking at - an eye pointing	Service(s): intelligent control of the environment; navigation services; agent-based information, communication and negotiation services; multimedia interpersonal communication services; relay services. Functionalities: user identification; user modelling (personalisation); automatic media transduction; reasoning (intelligent agent) about the goals of the user; guidance in the environment.

instrument used.	system is also able to spot the zone of the artefact she is looking at for some time. The AmI knows that Maria is an art student and it is able to match her known or perceived needs. For example, on the basis of the time available and the number of artefacts to be considered, it can estimate the amount of information that can be made available. This estimation can be reiterated after each item. If AmI is allowed to have personal information about Maria, offered by her or constructed through data collected during multiple visits, AmI can also personalise the presentations and suggest possible changes to the planned visit.	
The AmI, when allowed, is able to track the positions of all persons. In particular, Maria's P-Com knows all her friends and can ask the AmI if some of them are in the concert house at the moment.		Service(s): alarm and support/control services; navigation services. Functionalities: people localisation and tracking
If this is the case, it can ask them if they are available for a short exchange of comments during the interval.	If this is the case, it can ask if they are interested in visiting the exposition with Maria. As a matter of fact, according to a recent research, it is clear that visiting museums is considered a social activity and people like to share the experience. As soon as a group is formed, AmI reprograms itself in order to take into account the needs of all the participants in the group and not to be too invasive, offering information only if explicitly asked.	Service(s): intelligent control of the environment; (group) multimedia interpersonal communication services; agent-based information, communication and negotiation services. Functionalities: user identification; user modelling; mediation (intelligent agent) about the goals of the individuals in the group.
A final drink?		
When the activity is over, the friends discuss about having a last glass of wine together before going home. In the vicinity there is a very nice wine shop. Maria's clothes appear perfectly normal, but a lot of sensors are embedded,		

because she has some minor heart problems. A health control centre is continuously monitoring her health parameters and activities. Apparently, everything is ok, but it has been a long and busy day. Why not to go home and relax? Maria accepts the advice of the medical centre and declines the gentle offer.	

7.2.2. Scenario 2 – Jane: an old lady in her house

Jane Scenario	
Script	Services
Control and interaction with the environment	
In the kitchen	
When Jane wakes up in the morning the rooms of her apartment adopt her 'personality' as she enters.	
Ms Jane Smith is 75 years old. She does not have any really disabling health care problem. She has a reduced sight and hearing and starts to forget what to do. She is waiting for her milk to be warm, when the fridge starts to speak: "Jane, did you forget that tonight your granddaughter and her husband will have dinner with you?" Ms Smith does not want to admit that the fridge is right. Therefore she replies: "Obviously I did not forget. Can you suggest a menu for the dinner?" The fridge knows the culinary habits of her relatives. They are usual guests. It proposes a list of dishes. The menu is right, but with the present economic crisis the fish is too expensive. Can the fridge suggest a less expensive alternative? Ms Smith agrees with the following proposal of the fridge, but asks for a new recipe. The fridge searches the web and selects some new recipes on the basis of the known tastes of the guests. After the selection, the fridge finds out what is lacking for the preparation of the dishes by interrogating the RFIDs available on all items in the kitchen. Then it is authorized by Ms Smith to connect with the supermarket. It buys what is lacking within the authorised expense limits and agrees on the delivery compatible with the preparation. Finally, the kitchen programs itself for activating on time the necessary components (e.g. the oven) and to guide Ms Smith in the preparation of the dinner. In the meantime the gas under the milk kettle has been switched off on time to avoid spilling and Ms Smith has been notified that the milk is ready.	Service(s): intelligent control of the environment; alarm and support/control services; environmental control services; agent-based information, communication and negotiation services; relay services; e-shopping. Functionalities: user modelling; reminder service; identification of (tagged) objects; intelligent recommending service (intelligent agent); gas control; automatic transduction of information; financial transactions; negotiation with the supermarket.

After breakfast, Ms Smith heads for the living room, where she left her book last night. While passing in front of the bathroom door, she is notified that the water has been warmed at the requested temperature. She replays that she does not feel ready to take the bath now and instructs the bathroom to keep the water at the preferred temperature (probably this in not ecologically correct. The bathroom should tell her, but considering that the lady 75 years old, it decides to forget it). While Ms Smith is moving through the house, the lights are switched on for the time necessary for the blinds to open.	Service(s): intelligent control of the house; alarm and support/control services: Functionalities: user modelling; safety services.
When in the living room, the radio is switched on. Ms Smith likes to know what happens in the world and the house knows it. Obviously, the radio would have been switched on in the kitchen, if she would have not moved. After the news, the radio tunes on the classic music channel normally listened to by the lady. This morning Ms Smith prefers to read and tells the radio to switch off. However, she does not remember where she left her reading spectacles. She thinks that they are in the living room, but where? Fortunately the spectacles have an RFID on them. Therefore it is only necessary to tell the house to localise them. They can emit a signal (auditory or visual). Otherwise the house can tell Ms Smith where they are.	Service(s): intelligent control of the house; alarm and support/control services; environmental control services. Functionalities: position tracking; user modelling; identification of (tagged) objects.
Looking at Ms Smith, one would see an old lady with an informal house dress. But her dress is not normal, even if it is impossible to realise it. Her clothes are “intelligent”, meaning that sensors are embedded in them able to take under control parameters connected to her health status (measuring, for example, temperature, blood pressure, and the stress status). These sensors have a wireless connection with a memory system and, if necessary, they can be transmitted in real time to a medical centre. This is the case with Ms Smith. Recently, she had some problems, and, even if, minor, the doctors prefer to take her under control. Nothing serious, but given the age, it is better to be careful.	Service(s): alarm and support/control services Functionalities: monitoring of health parameters; transmission to a control system

Suddenly, a portion of the wall in front of Ms Smith lightens. A moving projector is able to transform in a screen any surface in front of the lady. It is a video telephone call by the control centre. Ms Smith is not concerned. It happens every day. She knows and likes the doctor and it is pleasant to speak with a nice girl. She accepts the call and switches on the TV camera, because she likes to be seen. The doctor tells her that her data have been checked and everything appears under control. On the contrary, an improvement in the general status appears and she can skip the pill at 4 p.m. (the house reprograms itself to skip the alarm at 4 p.m.). After a short conversation, the communication is switched off. This is the routine procedure. Obviously, if one the vital parameters of Ms Smith would appear outside limits, the medical centre would be alarmed immediately. Concerning the support to memory, Ms Smith gets suggestions for the fundamental activities, related to the medical therapies but also to the normal domestic activities and to the social relations in a form matched to the contextual needs. For example, if she is listening to music a light signal is activated to attract her attention, while is she is reading a voice message will be spoken.	Service(s): multimedia interpersonal communication services; intelligent control of the house; alarm and support/control services; broadband communication facilities. Functionalities: reminder service; e-health service.

The clock on the wall, the flowerpot on the table and other objects in the living room appears as normal furniture, but looking at them some details can be noticed, whose functions is not immediately clear. For example, on the clock-face it is possible to see a small hole covered with glass. Actually, it is a video camera. In the house it not only possible to take under control the health status of a person, but also the person. It is possible to know, where she is, what is doing, if she move in a manner compatible with the on-going activity or, for example, if she move with difficulty or worse if she is falling. Normally the data are available only to the house control system that can reason and take decisions to support the person or sending outside an alarm, if necessary. The data are not visible from the outside, unless there is an explicit authorisation by the inhabitant or an alarm situation. Ms Smith tripped up on the carpet while looking for a book and fell, fortunately on the couch. The house control system has identified the fall and has sent an alarm to the external service. Ms Smith is afraid to fall and to hurt herself. Therefore she has authorised the house control system to activate the video cameras if she falls. The person in the service centre can see that Ms Smith has fallen on the couch, without any harm. She speaks for some minutes with her and then starts again the alarm system. Obviously, there is redundancy in the system. If the control centre cannot intervene, for example because it is overloaded, the call is transferred to relatives of friends with a predefined order.	Service(s): intelligent control of the house; alarm and support/control services; environmental control services. Functionalities: position tracking; movement tracking; fall identification; alarm to an external service.
The video-telephone service is again switched on. Ms Smith's daughter is calling her. The grandchild has lost his first milk tooth and the daughter wants to show her how he is funny with a small hole in the middle of his mouth.	Service(s): broadband communication facilities; multimedia interpersonal communication services..

8. Services for people with activity limitations?

8.1. Introduction

The analysis of the above scenarios shows that the life of people in a AmI(-like) environment can be facilitated by the availability of different services offering different functionalities. In order to simplify discussion, the functionalities have been organised according to the following services:

- Environmental control services (including all traditional environment control technologies and systems);
- Relay services (automatic transduction/translation of information);
- Agent-based information, communication and negotiation services;
- Navigation services;
- e-activities: eLearning, e-shopping etc.;
- Alarm and support/control services (including e.g. traffic control etc.);
- Broadband communication facilities;
- Multimedia interpersonal communication services.

They refer to service typologies already existing, even if generalised. For example, relay services include any type of transduction of information and/or language translation.

In addition, the generic service “intelligent control of the environment” is added. This does not refer to any specific service, but tries to emphasise the fact that, probably, the main difference in future will be in the level of intelligence built in the environment, in addition to services for environmental control and alarm/control.

Some questions remain open, as, for example the following:

- Are the above services special service or general services necessary and available for all citizens?
- If they are general purpose services, is it necessary to take particular care in setting them up due to the fact that some citizens have activity limitations?

8.2. The environment as a general facilitator

So far, the inclusion of people with activity limitations has been based on some complementary approaches: adaptation of systems addressing the needs of individual user groups (e.g., by adapting their human computer interfaces), adaptation of services of general use (e.g., alarm services), and creation of special services (e.g., relay services).

Some interesting conclusions can be drawn from the scenarios, with reference to services available in the environment. This section addresses issues related to the environment’s foreseen functionality, envisaging how it can potentially impact on inclusion.

Environmental control systems

Environmental control systems, introduced for the independent living of persons with motor disabilities, become an integral part of the living environment. Probably, the environment will not be equipped by default with robot-type systems useful for taking care of certain needs of people with motor disabilities, such as feeding them or moving them around. However, it will be able to integrate this additional technology if it is has been designed in such a way as to be extendable to incorporate additional facilities (either for general purposes, e.g., robotic systems, or for specialised support, e.g., assistive technologies).

Relay services

Another type of service (*relay services*) of interest for people who cannot hear/and or speak is in principle available by default in the Ambient Intelligence environment, where voice recognition and synthesis, automatic translation, gesture recognition (sign language and lip reading) and animation (synthetic sign language and lips movements) are available.

Agent-based information, communication and negotiation services

The real winning factor is the intelligence in the environment (intelligent agents). For example, to organise a trip abroad a user may rely 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. This intelligent support, of interest to everybody, can be crucial for people who have some hearing or speech problems that can reduce interpersonal communication or sight and manipulation problems that can reduce efficiency in accessing complex information services. The possibility of delegating to an agent the transactions needed for organising a trip abroad can also be crucial for an older person with cognitive limitations.

Navigation services

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 many scenarios for different purposes. If a user is not able to see, a personal communicator in communication with AmI can guides them through the airport (e.g., by voice, or using haptic cues). This requires positioning information and the possibility of controlling the presence of unpredictable obstacles (people, baggage, etc.), obtainable through the use of features of the AmI itself (e.g., a control system able to monitor tagged objects and communicate with passengers). If the user has cognitive limitations, the navigation system may tune the level of support to the known abilities or to the perceived present difficulties. If unable to see, navigation help may be provided, and so on.

Learning activities

The space as well as the organisation of 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.

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 a user's behaviour in the various environments according to known habits and intervene if necessary, for example reminding of tasks and helping to perform them. When necessary, AmI can also contact the family or a carer for advice and help. If necessary, AmI is able to describe its layout and functionalities, as well as the functionalities of its devices (e.g., the remote control of the hotel room). Moreover, AmI is able to organize sequentially the flow of information and the performance of the necessary tasks, allocating the necessary time.

Broadband communication facilities

The additional opportunities offered by AmI are related to the availability of *broadband communication facilities*. The possible scenario of a user travelling abroad offers a presentation of advanced telecommunication facilities, in the car, in the hotel room and in the presentation room. When driving, the user is tracked by the navigation system and people know (if she wants) that she can be contacted. 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.

Audio/video interpersonal communication services

Even if support by technology can be invaluable 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.

8.3. Intelligence in the environment

Intelligent agents seem interesting to offer focused services to people. They normally address a single "intelligent" task and try to mimic the behaviour of the owner. The problem is much more difficult when the entire environment or complex parts of it must be controlled in a way to show behaviour that people can consider "intelligent". The problem is too far reaching to be tractable in this document. Only, some examples will be made in order to give an idea of the complexity of the involved problems. At the technological level, artificial intelligence is crucial in supporting the development of basic technologies considered important in the implementation of AmI. For example, the ISTAG experts write that pattern recognition (including images, speech and gesture) is a key area of artificial intelligence which is already evolving rapidly and should improve significantly the situation.

At the level of interaction, a smart environment may provide an extremely large number of complex choices. An interface that directly offers all the possibilities to the user may result in it being cumbersome and complex. On the contrary, the user interface should act as an intelligent intermediary between the system and the user. This is the reason why Artificial Intelligence methods and techniques are starting to be used for the development of adaptive intelligent interfaces. Intelligent interfaces are first supposed to be able to adapt to the user's physical, sensorial and cognitive capabilities, some of which may be restricted due to aging or impairments and/or may change along the day, due to e.g. fatigue, and changes in motivation. To this end, the interface must have a model of the users and be able to make “assumptions” about their actual situation from the current value of a number of parameters as measured by intelligent interface must be able to recover from errors in adaptations.

Another important characteristic of the human interfaces for smart environments is their spatial dependency. Many features and possible effects of interaction depend on the position of the user. For instance, a simple command as "switch on the lights" must be differently interpreted according to the place where it has been given. Provided that the user is located with enough precision, the interface needs a spatial model to be able to decide what the lights to be switched on are. In addition, the interface, in order to avoid potential dangers, must be able to decide the services that can be offered to the user in the current location. In contrast to graphical user interfaces, ambient user interfaces should take advantage of the available AmI Infrastructure, in order to support interaction that is tailored to the current needs and characteristics of a particular user and context of use. Thus, they could be multimodal and distributed in space (e.g., employ the TV screen and stereo speakers to provide output, and get input through both speech and gestures), allowing interaction with the ambient technological environment in an efficient, effective and intuitive way which also guarantees their well-being, privacy and safety and supporting seamless, high-quality, unobtrusive, and fault-tolerant user interaction.

Moreover, the AmI environment must take care of the contexts of use. In AmI, the situation is very complex, because in the ubiquitous interaction with information and telecommunication systems the context of use may change continuously or abruptly and the same systems or services may need to behave differently in different contexts. Recently, research tendencies have evolved to consider context not statically, but as a process, defined by specific sets of situations, roles, relations, and entities. It is not sufficient for a system to behave correctly at a given instant, but it must continue to behave correctly for the entire process. This requirement is coherent with the idea that in AmI intelligence must be essentially in the environment and not in the individual objects. Functionalities will be surely more easily available if they can migrate through the network, instead of being entrapped in objects.

Another important issue is avoiding the risk of a possible mismatch between the model of interaction of the system and the user’s mental model of it. As a matter of fact it must be considered that in today systems, designers have pre-programmed solutions for the design space of the systems, while in AmI the interaction space is ill defined and unpredictable. In a context, defined as above, three level of abstractions exist: the sensing level (numeric observables), the perception level (symbolic observables), and the level of the identification of situation and context. This is the level where the conditions for moving between situations are identified and anticipate needs of the user and of the system. This requires replacing explicitly coded responses to situations and contexts, with a higher-level, more knowledge-intensive use of machine-readable strategies coupled with reasoning and learning.

At the level of intelligent support, additional complexity can be inferred if the main specifications of an AmI environment are considered. According to ISTAG, the ambient intelligence environment must be unobtrusive (i.e. many distributed devices are embedded in the environment, and do not intrude into our consciousness unless we need them), personalized (i.e. it can recognize the user, and its behaviour can be tailored to the user’s needs), adaptive (i.e. its behaviour can change in response to a person’s actions and environment), and anticipatory (i.e. it anticipates a person’s desires and environment as much as possible without the need for mediation).

Therefore, in AmI the emphasis is on (abstract) goals of the users that the environment must infer and structure in a set of tasks adapted to the users themselves and the context of use (for example without interfering with the goals of other persons in the same environment).

The acceptability and uptake of the new paradigm will be essentially dependent on how smart the system is in inferring the goals (desires) of the users in the varying contexts of use and in organising the available resources (intelligent objects, services and applications in the environment) in order to help users to fulfil them. This means that an “intelligent” control must be available. So far most of the available control systems are deterministic. This is not compatible with the emerging situation for two main reasons. The first is that AmI is not only concerned with measurements from sensors, but with goals of people to be fulfilled and interaction in a social context. Moreover, it must take into account that the emerging model may be a social group interacting in order to cooperate for carrying out activities connected with independent living and interactions within a social environment.

Finally, ambient intelligence is also supposed to inspire trust and confidence and to be controllable by ordinary people. The requirement about trust and confidence is very challenging, because they can be obtained only if the user has a complete knowledge at the conceptual level of the running principles of the systems, services and applications and is given the possibility of controlling all the steps necessary to obtain the required results. For what concerns control by ordinary people, in some discussions, a simple and naïve concept is assumed, i.e. that the user is given the possibility of switching off the system, service or application. But the problem is not so simple. For example, switching off the telephone can be a problem if a user is connected through it to an alarm system or a health care monitoring system. Therefore, it is necessary that the AmI environment is able to cooperate with the users, according to their profile (e.g. culture, technical knowledge, and possible impairments), the context of use, and the emotional situation in order to find a compromise between privacy or fatigue etc., and possible security aspects.

9. The triggering question

Today, there is an increased concern that developments in society could be too influenced by the technological push and, therefore, it is necessary to discuss the sustainability of the foreseen changes. For example in the last ISTAG document (ISTAG 2011), the European experts write

"*A balanced progress perspective is needed here: the future requires a continuous balancing of often contradictory individual, social, societal, entrepreneurial, and ecological needs. We cannot simply assume that technical developments in ICTs will lead to socio-economic progress. We need to ask ourselves why and when we need more transistors, faster clock speeds, and more bits. More than ever we need to put human beings in their social environment in the centre. We need to articulate and communicate what social objectives publicly funded innovation aims at. This requires both the involvement of new stakeholders and a stronger focus on social innovation. Social innovation refers to new strategies, concepts, ideas and organisations that meet social and societal needs. In our view technological innovation and social innovation are inextricably linked and inter-connected in the near future, as the eInfrastructure is growing out to be a basic and vital societal infrastructure. This mutual shaping process implies an understanding of ICTs as a transformative force that redefines both problems and solutions. This not only involves a new approach towards R&D&I, but also requires new indicators to measure productivity, growth, development, and progress.*"

The technological trends seem well established as shortly summarised in the present document. From the perspective of people with activity limitations, it seems that most of the technology of interest for their inclusion (for example the first application of voice synthesis was in screen readers for blind people) will now become of interest for products for the general public. Moreover, services that until now have been set up to support people with activity limitations (for example environmental control systems, remote control, navigation) are foreseen as part of the very fabric of the Information society.

However, there is always a concern at the back of the mind of people working in eInclusion. There will be a really positive impact, only if the technology and services to be developed take explicitly into account all people who potentially need them. Thus, the purpose of this SDDP is to clarify the meaning and importance of this "if" and to propose activities necessary, if any, for favouring the emergence of an Information Society where telecommunication services are really instrumental in granting equal access to all opportunities, by all.

In order to initiate discussion in the SDDP, the following triggering questions has been formulated:

What research actions should be supported to exploit emerging network infrastructures and services to facilitate eInclusion?

References

Aarts, E. & Diederiks, E., ed. (2006). “Ambient Lifestyle: from Concepts to Experiences”, BIS Publishers, Amsterdam.

Aarts, E. & Marzano, S., (2003). “The New Everyday views on Ambient Intelligence”. Rotterdam: OIO Publishers.

Abowd G., Mynatt E., Rodden T., (2002). “The Human experience”. *IEEE Pervasive Computing*, 1 (1), 48-57.

Berners-Lee, T., Hendler, J. & Lassila, O. (2001). 'The Semantic Web', *Scientific American*, 34-43.

Burzagli, L., Billi, M., Gabbanini, F., Graziani, P., Palchetti, E. (2004). The Use of Current Content Management Systems for Accessibility. 9th International Conference on Computers Helping People with Special Needs, ICCHP 2004, Paris 7 - 9 July.

Emiliani, P., L., Burzagli, L., Billi, M., Gabbanini, F., Palchetti, E. (2008). Report on the impact of technological developments on eAccessibility. DfA@eInclusion Deliverable D2.1. available at: http://www.dfaei.org/deliverables/D2.1.pdf .

Emiliani P.L (2009). Perspectives in Accessibility: From Assistive Technology to Universal Access and Design for All, in “The Universal Access Handbook”, C. Stephanidis (Ed.), CRC Press - Taylor and Francis Group, pp. 2.1 – 2.18.

Emiliani, P., L., Aalykke, S., Antona, M., Burzagli, L., Gabbanini, F., Klironomos, I. (2009). Document on necessary research activities related to DfA. DfA@eInclusion Deliverable D2.6. Available at: http://www.dfaei.org/deliverables/D2.6.pdf .

Estrin D., Culler D., Pister K., Sukhatme G., (2002). “Connecting the Physical world with pervasive Networks”, *IEEE Pervasive Computing*, 1 (1), 59-69.

Geer D., (2004). “Will gesture recognition technology point the way?”, *IEEE Computer*, 37(10), 20-23.

Howard-Spink, S. (2002). “You just don't understand!”, Retrieved October 24, 2006 from http://domino.watson.ibm.com/comm/wwwr_thinkresearch.nsf/pages/20020918_speech.html.

Murugesan, S. (2007). “Understanding Web 2.0”, *IT Professional* **9**(4), 34-41.

IMS (2002). “Guidelines for Developing Accessible Learning Applications”.

ISTAG (2003). “Ambient Intelligence: from vision to reality. For participation in society and business”, Information Society Technologies Programme of the European Union Commission (IST).

ISTAG (2011). Orientations for EU ICT R&D & Innovation beyond 2013.

Kurzweil, R. (2001). “The law of accelerating returns”, Available at http://www.kurzweilai.net/meme/frame.html?main=/articles/art0134.html.

Lindström, J.-I. (2007). “Safe navigation with wireless technology”, in “Towards an inclusive future”, P. R.W. Roe ed., Published by COST, Brussels, 2007 pp 9-23.

Lorincz, K., Malan, D., Fulford-Jones, T., Nawoj, A., Clavel, A., Shnayder, V., Mainland, G., Welsh, M., Moulton, S., (2004). "Sensor Networks for Emergency Response:Challenges and Opportunities", *IEEE Pervasive Computing*, 3(4), 16-22.

National Council on Disability, Vaughn, J. (Chairperson) (2006). "Over the Horizon: Potential Impact of Emerging Trends in Information and Communication Technology on Disability Policy and Practice", Technical report, Washington.

Roe, P. Ed. (2006). "Towards an Inclusive Future: Impact and Wider Potential of Information and Communication Technologies", COST, Brussels.

Zimmermann, G., Vanderheiden, G., Ma, M., Gandy, M., Trewin, S., Laskowski, S. & Walker, M. (2004). "Universal remote console standard: toward natural user interaction in ambient intelligence", *in* 'CHI '04: CHI '04 extended abstracts on Human factors in computing systems', ACM Press, New York, NY, USA, pp. 1608-1609.