

Science and Technology Roadmapping: Ambient Intelligence in Everyday Life (Aml@Life)

JRC/IPTS - ESTO Study

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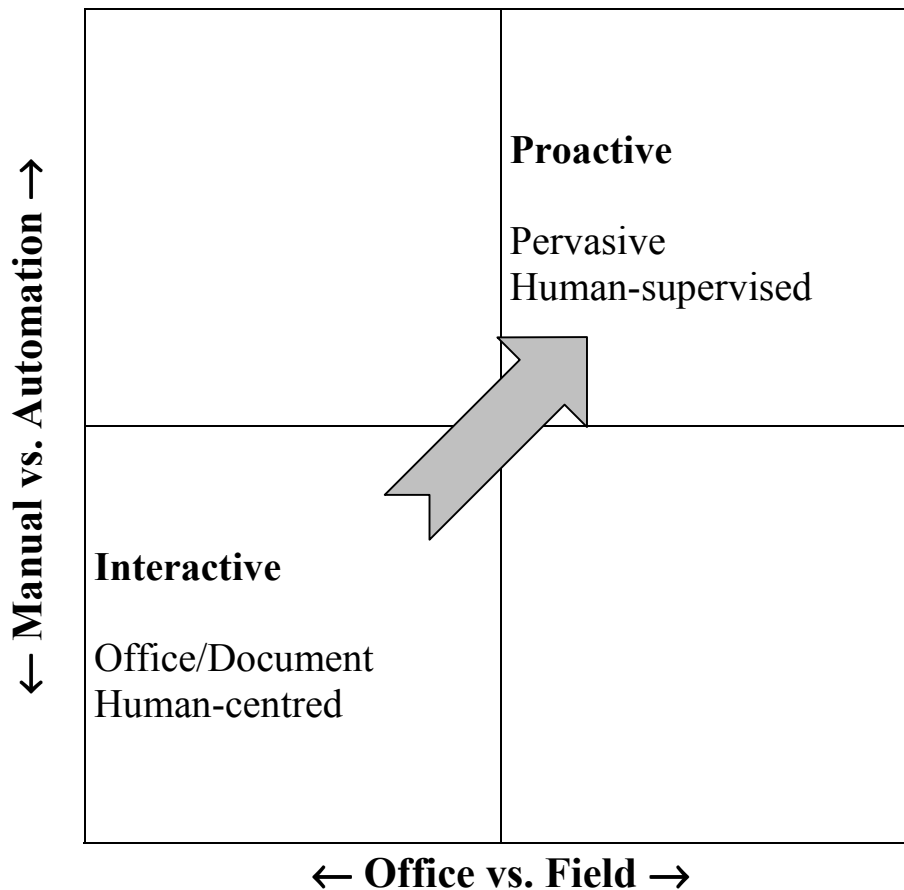
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1 Introduction to Ambient Intelligence

1.1 The Vision of Aml

The concept of Ambient Intelligence, being developed in the ISTAG reports (ISTAG 2001, 2002), provides a vision of the Information Society future where the emphasis is on user-friendliness, efficient and distributed services support, user-empowerment, and support for human interactions. People are surrounded by intelligent intuitive interfaces that are embedded in all kinds of objects and an environment that is capable of recognising and responding to the presence of different individuals in a seamless, unobtrusive and often invisible way.

Figure 1: The shift from interactive to proactive computing



The vision of Aml assumes a shift in computing from desktop computers to a multiplicity of computing devices in our everyday lives whereby computing moves to the background and intelligent, ambient interfaces to the foreground. Related shifts are put forward in the FP 6 IST Workprogramme for 2003-2004.

The programme also argues that “realising the (AmI) vision requires a massive and integrated research effort that addresses the major societal and economic challenges and ensures the co-evolution of technologies and their applications”.

Table 1: IST today and in FP6

IST today	The IST in FP6 vision (AmI)
PC based	“Our surrounding” is the interface
“Writing and reading	Use all senses, intuitive
“Text” based information search	Context-based knowledge handling
Low bandwidth, separate network	Infinite bandwidth, convergence
Mobile telephony (voice)	Mobile/Wireless full multimedia
Micro scale	Nano-scale
Silicon based	new materials
e-Services just emerging	Wide adoption (e-Health, Learning,..)
< 10% of world population on-line	World-wide adoption

This vision of AmI places the user at the centre of future development. Therefore the technology should be designed for the people rather than making people adapt to the technology. It is less clear however, how this can be realised. We propose to implement a holistic approach that takes into account that socio-technological systems always have three dimensions: a technological, a social and a policy dimension.

1.1.1 The technological dimension

The ISTAG scenarios report on Ambient Intelligence identified a number of key technological requirements for AmI to become real. These are:

- Unobtrusive hardware (miniaturisation and nano-technology, smart devices, embedded computational power, power consumption, sensors, activators, etc.)
- A seamless mobile/fixed web-based communications infrastructure (interoperability and dynamically reconfigurable wired and wireless networks)
- Dynamic and massively distributed device networks (interoperable devices and ad-hoc configurable networks, network embedded intelligence, etc.)
- Natural feeling human interfaces (intelligent agents, multi-modal interfaces, models of context awareness, etc.)
- Dependability and security (robust and reliable systems, self-testing and self-organising/repairing software, privacy-ensuring technologies, etc.)

The keywords are systems and technologies that are sensitive, responsive, interconnected, contextualised, transparent and intelligent.

The IPTS/ISTAG AmI research was broad and applied to different environments: work, personal communication, community/learning and urban transport. In contrast, this project focuses on the everyday life.

The question then is if and how the above-mentioned generic AmI key technologies are applicable within everyday life context? Will it be necessary to identify competing key technologies?

1.1.2 The social dimension

Social, economic and geo-political trends are influencing, to a major or minor extent, everyday life. Some of these are an ageing society, a mosaic society, a multi-cultural society, the European Enlargement, life-long-learning, consumerism, (anti-) globalisation, etc. Many of them are triggered by IST developments and should thus be taken into account.

Research on use and acceptance of ISTs also shows that it is not obvious that everyone will accept and use AmI technologies in their everyday lives. It is known that:

- People do not accept everything that is technologically possible and available.
- People need resources/capabilities to buy and use ISTs (money, time, skills, attitudes, language, etc.) that are not evenly distributed in society.
- People make use of new technologies in ways that are very different from the uses intended by suppliers (e.g. the Internet, SMS).
- New uses of ISTs mainly emerge in interaction of users and producers of ISTs.
- User demands will only be met if costs are attractive for the suppliers.
- There is no such thing as a typical, standard user and use but rather a diversity of users and uses.
- There is a difference between ownership, usage and familiarity of ISTs. People own technologies but may not use them; people use technologies but may not have trust and confidence in them. Today, the PC and the Internet have not gained the same degree of diffusion as television, radio and telephone.

1.1.3 The policy dimension

According to the Lisbon European Council of 2000 and the e-Europe Action Plan (prolonged to 2005), the Commission is committed to ensure European leadership in generic and applied knowledge society technologies, to improve European competitiveness and to enable all European citizens to benefit from the knowledge society. The Lisbon process clearly stated that the European knowledge based society should also be a socially inclusive one.

This places topics of the digital divide and of access to ISTs on the policy agenda. Public policy is needed to address these issues. New technologies should not become a source of exclusion for society. Therefore security, trust and confidence were recognised as key bottlenecks for the deployment of AmI.

The notion of universal access is preferred over the term digital divide because it leaves room for voluntary exclusion (Stephanidis 1999, Punie 2003). People may say “No” to AmI@Life but they need to be able to say yes if they want it. Universal access is therefore not limited to

access to infrastructures. It includes access to services and applications as well as access to the necessary resources to make use of AmI in the home/everyday environment.

1.2 The Issue: Trusted and Universal Access to Ami@Life

Addressing the problem of universal and trusted access to Information Society Technologies (ISTs) is today discussed and researched in many different ways, but a key challenge consists of framing the problem in a prospective way. Universal access to ISTs, encompassing technical, social and economical dimensions, as well as securing its use should be pro-actively taken into account in research, development and the design of new technologies, in contrast with reactively trying to influence their diffusion in society.

The key question then consists of designing new technologies that have the potential to include everyone, that are affordable and build trust and confidence. This could help public policies in preventing new technologies from becoming a (new) source of exclusion in society.

This project focuses on Ambient Intelligence (AmI) Technologies since the vision of AmI assumes seamless, unobtrusive, and often invisible but also controllable interactions between humans and technology.

The project's focus is further delimited to the context of the everyday life of European citizens, to make a clear distinction with AmI in the professional sphere. AmI in everyday life (AmI@Life) requires specific attention because there is no simple spill over of technologies from the office to the home or vice versa. Also there is the already mentioned policy concern of exclusion or uneven distribution of private access.

There is no inherent guarantee that AmI@Life will be inclusive for everyone. Of course it should not only be designed for the urban, highly educated and mobile techno-freaks, but also for low-tech, ubiquitous use in the lives of most people to improve their everyday life. It should also be trustworthy, thus requiring the same degree of sophistication (with regard to privacy and security) as AmI in the professional sphere.

AmI should be designed in such a flexible and diverse way that it a variety of users will feel at home with it. Also it should support a diversity of uses and context of uses (leisure, education, work, family life, social life). People seamlessly migrate from being receivers, users, producers, consumers and citizens of media, information and communication in their everyday lives. AmI design should reflect this.

The key question is: how can intelligent and dynamically changing systems be made accessible, trustworthy and useful within the context of the regularities and irregularities of our everyday lives?

2 The IPTS/ESTO AmI@Life Roadmapping

2.1 Introduction

“Ambient Intelligence in Everyday Life (AmI@Life)” is one of the two pilot S&T roadmaps developed at IPTS (Institute for Prospective Technological Studies) of the European Commission’s Joint Research Centre in collaboration with the ESTO (European Science and Technology Observatory) network. The other pilot roadmap is on “*The delivery of Healthcare in the context of an ageing society*” analysing the “likely technological pathways to the effective delivery of healthcare in an ageing and diverse European society”.

AmI@Life roadmap focuses on “trusted and universal access to Ambient Intelligence technologies within the context of everyday life”, raising the potential of full IST integration in the everyday life of ordinary European citizens. It endorses a specific approach directed towards everyday life outside the professional sphere. Indeed, AmI in everyday life requires specific attention because there is no simple spill-over of technologies from the office to the home. Also there is the already-mentioned policy concern of exclusion.

2.2 The Objective

The objective of roadmapping universal and trusted access to AmI technologies is to understand how different technologies might affect the digital divide and to depict scenarios that enable us to think about them in a dynamic, flexible and prospective way.

It is therefore not the aim to provide concrete solutions to digital divide problems. Not only technologies that are user-friendly will be considered. Rather the project shall raise the potential of full IST integration in our everyday lives. This requires a balanced approach, taking into account the key socio-cultural, economical and technological issues affecting trusted and universal access to AmI@Life.

Therefore the main aim of this ESTO study is to investigate the potential of AmI technologies in various key application areas relevant to Everyday Life. The impacts on both the supply and demand side will be examined. A specific focus will be to identify and analyse trends and possible trend breaks.

In order to deepen our understanding, the roadmap was focused and detailed by referring to key application areas where AmI technologies were expected to have major consequences for a broad range of citizens in their everyday life and by giving a first qualitative assessment of major questions and challenges in selected fields.

2.3 Presentation of S&T Roadmapping

Numerous methods are used in prospective technological studies including: Scenarios, Delphi, Environmental Scanning, Expert Panels, Brainstorming, SWOT (Strengths, Weaknesses, Opportunities, Threats) Analysis, Trend Extrapolation, Simulation Modelling, Cross Impact Analysis, Critical/Key Technologies, Relevance Trees, Morphological Analysis, etc. S&T Roadmapping is one of them.

The terminology “Technology Roadmapping” (TRM) is used to designate studies encompassing visions of future possible technological developments, products or environments (Da Costa et al. 2003). One common feature of the various definitions put forward is that the output usually includes graphical representations in which “nodes” (past, present or future steps of S&T development) are connected by “links” (causal or temporal relations). Two key interrelated functions can be seen to emerge.

- Firstly, TRM produces representations of the state of the art of S&T at a certain point in time and of the nature, rate and direction of potential S&T developments. TRM is therefore a prospective methodology.
- Secondly, the representation is put to practical use in negotiating the way forward and in informing decisions about possible future options. As such, a roadmap is also a planning methodology: *“a traveller's tool that provides essential understanding, proximity, direction, and some degree of certainty in travel planning.”* (Kostoff and Schaller 2001)

Technology roadmapping has originally been developed as a R&D management and foresight methodology in industry since the mid-1980s. As the concept and methodologies have matured, it has come to be applied in an increasingly broad range of areas, from single individual companies (Corporate TRM), to entire industry sectors (Industry TRM), trans-disciplinary hi-tech common goals (goal-oriented TRM) or the provision of intelligence for S&T policy-making (S&TRM for Policy Intelligence).

In this context, it is used for displaying and synthesising networks of past, present and future stages of S&T developments, causes or solutions to a problem, and for highlighting the necessary steps to reach the market with the right products at the right time (Garcia and Bray 2002). It traditionally endorses a “technology-push” approach.

2.4 Function Oriented Approach

Traditional technology roadmapping tends to focus only on the development trajectories of technologies to provide new products (Corporate TRM) or on detailed enabling technologies in the pre-competitive domain (Industry TRM). A “function-oriented” approach has been de-

veloped in order to give a fuller account of the “innovation chain”, also including non-technological factors:

- S&T developments,
- Applications,
- Key functions,
- Users.

The “function-oriented” approach constitutes an intermediate way between the technology-push and the user-pull approach. It consists of the following three, interrelated dimensions or axis which are considered orthogonal within our modelisation:

- Identifying *key functions* where AmI is expected to “make a difference”. Focussing on functions enables to take into account both foreseeable AmI applications and everyday behaviour (social trends).
- Identifying the *key technologies* that are needed for the development of the AmI applications and/or functions.
- Mapping these developments over *time*, using a yearly time scale and a time horizon of up to 15 to 20 years.

As it is not feasible to investigate the interactions between these three dimensions at once, the following three pairs are studied:

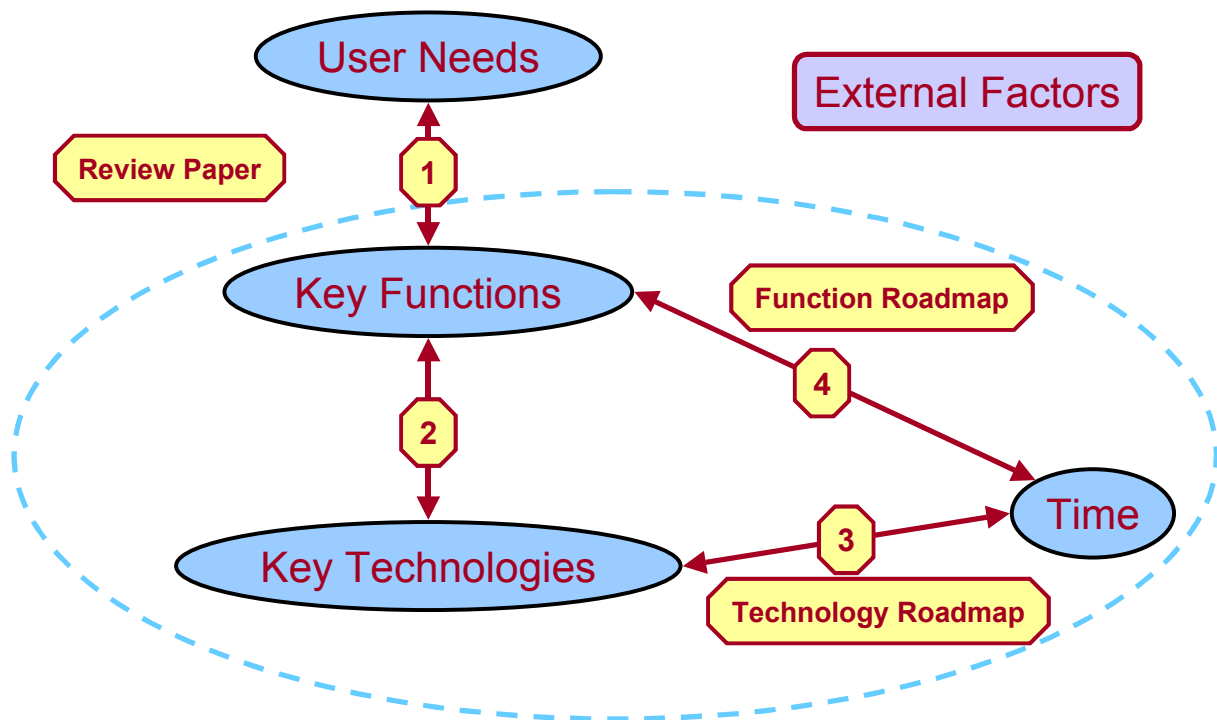
- Key Functions and Key Technologies
- Key Technologies and Time
- Key Functions and Time

2.5 Methodology

The process consists therefore of the following four successive but interrelated steps (see figure 2):¹

¹ For the methodological approach of Roadmapping in general see Garcia and Bray 1997, Möhrle and Isenmann 2002 and Da Costa et al. 2003.

Figure 2: Methodological Approach of the Project



2.5.1 Application Areas

The project started with a “problem-definition workshop” including the project partners² and external experts. During this brainstorming, the broad field of “Everyday Life” was divided into application areas shared between partners according to their respective expertise. These application areas were defined as Housing, Mobility and Transport, Shopping and Commerce, Education and Learning, Culture, Leisure and Entertainment as well as Health.

This leaves out other important areas of application – especially the professional life in general. Purely business and corporate issues are excluded from this roadmap. Though working is an important part of our Everyday Life, the needs addressed by technologies are normally not expressed by the individual but by a business unit. Purely business application as in manufacturing and logistics normally do not touch individual needs at all. Work was only included as far as it takes places in a home environment. This is addressed in ‘Housing’.

2.5.2 Key Functions

The second step was to identify some of the key functions to which “AmI can make a difference” in each of these application areas.

² The partners are organisations members of the ESTO network: Fraunhofer ISI, ENEA, Fondazione Rosselli, TNO-STB, VTT and IPTS.

These first two steps are in themselves a strong statement because they imply that from the start the process was envisaged from the perspective of the applications and functions while in traditional roadmapping, the starting point would be the different key technologies.

2.5.3 Key Technologies

The third step is to link these functions to key technologies, the technologies being previously classified into “Broad Technology Area”, including Communication & Networking, Software, Microsystems & Electronics, User Interfaces, Displays, Knowledge Management, Artificial Intelligence, Trust & Security, and Power sources. It is worth noting that not all of these technologies are “AmI technologies” in the strict sense. Most of the IST have actually been included.

A matrix³ between the key functions and the key technologies is built and constitutes the first major output of the project. The description and analysis of the enabling AmI technologies are subject of Chapter 3.

2.5.4 Time

The fourth step is to construct the Technology and Function roadmaps themselves. The foreseen developments of key technologies versus time constitute the “Technology Roadmap”. It synthesises:

- Milestones;
- Potential breakthroughs or disruptions;
- Alternative scenarios;
- Co-dependencies, i.e. how different technologies need to evolve and come together at a certain point in time in order to allow a macro progress.

The potential trajectories of key functions/products versus time constitute the “Function Roadmap”. It is obtained from the integration of “Key Functions × Key Technologies” and “Key Technologies × Time”. It synthesises:

- Milestones;
- Potential breakthroughs or disruptions of different natures (S&T, economy, environment, society, demography, policy);
- Critical paths for the development of the key functions;
- Alternative scenarios;

In addition to these steps the most important limiting and enabling non-technical factors were explored during the analysis of the application areas and discussed during a “Vision Work-

³ A matrix is a table of rows and columns in two or more dimensions.

shop” that took place in March 2003, again with the participation of experts from academia, industry, and politics (see list of participants in the appendix). These factors are discussed in Chapter 6.

3 Application areas for Ambient Intelligence in Everyday Life

3.1 Housing

3.1.1 Introduction

Intelligent Home, Smart Home, Interactive Home and Home of the Future are buzzwords which have been exploited widely in the context of domestic technologies used at home. Some of these visions are more concrete and elaborated than some others. The vision of Intelligent home has lived for decades already.

New technology has improved the standard of living. It has also helped us and changed the way we are leading our everyday life. Improved productivity has been (and is) most of the times the main selling argument concerning new innovative domestic technology. Despite the fact that this is a solid argument concerning the actual technology, the social change and implications can make things look really different. A good example of this is a washing machine.

“Washing machine was pitched as a labour saving device, and even though initial models did not go through a cycle automatically or spin-dry, they did reduce the labour of wash day. However, washing machines arrived around the same time as a host of other devices, including hot water heaters, irons and indoor bathrooms. All of these technologies in concert changed users’ expectations of “acceptable” hygiene and washing: with so many consequences, why limit yourself to washing yourself and your clothes once a week? ... Over time, these devices changed society’s expectations about what things would be done, how often and by whom. Indeed studies of domestic technologies so not show conclusively that work was reduced; more significantly, some suggest that amount of unpaid work in the home done by women rose dramatically.” (Edwards and Grinter 2001)

Ambient intelligent environments are characterised by their ubiquity, transparency and intelligence (Aarts 2003). In the future we will see how technologies of Ambient Intelligence will change our way of life. Will it realise all the promises researchers are giving or is it just an illusion – offering easy living while creating increased complexity of life. The tasks charged on the Smart House (Scott 1998) are by no means negligible:

- It uses computers to help its inhabitants live a healthy, happy and safe life,
- It performs many tasks automatically to relieve the stress of managing the house,
- It integrates home, work, learning and leisure activities,
- It hides all the bizarre details of how it actually works.

In the following chapters, technologies, applications and social implications of ambient intelligence in the application area of Housing will be discussed. In this chapter, key references, trends and gaps in R&D will be covered and also an outline of the application area will be provided.

During the last few years the scientific literature in the housing field has become more diversified as concerns the topic of intelligent houses/buildings. The term "intelligent" has become somewhat outmoded or obsolete, being replaced by new approaches such as "aware house", "integrated environments" or "alive and interactive environments". Authors have diverted their interest in studying more the interaction between home and residents and related interfaces than technologies as "intelligent" in their own right. This change appears analogous to the shift of emphasis from techno-centred artificial intelligence towards human-centred ambient intelligence, ubiquitous intelligence/computing or versatile intelligence/computing.

The main trends driving the application of ambient intelligence technologies in the application area of housing can be identified as:

- acceleration of rhythm of everyday life, hectic and busy lifestyles, growing demands of efficiency and flexibility in daily routines,
- breaking up of the boundaries of time and space (increasing tele-presence),
- ageing of population, leading to a demand of elderly living longer in their homes,
- increasing demand of security and safety (e.g. due to rising crime rates),
- growing pressures to curb environmental problems and to save energy (to promote sustainable development and to compensate high prices of energy),
- increasing search for experiences and meanings (Rifkin 2000; Jensen 1999) (leading to building homes as media/entertainment centres),
- increasing need for home as a sanctuary (home as dedicated to privacy, rest and relaxation), technological way of life.

As Castells (1996, pp. 397-98) points out "home centeredness" is an important trend of the new society. People increasingly work and manage services from their home. Home itself is expected to provide a safe haven of communication and caring, rest, relaxation and entertainment. Paradoxically, home can be characterised as being "wired" in order to "unwire" (relax) its occupants.

There is a gap in analysing ambient intelligence in housing from the point of view of sense of community. The focus could be adjusted on studying the possibilities of smart house applications and technologies to support families and friends being together and interaction between each other. More emphasis should also be put on analysing and anticipating the needs and desires of residents of smart houses. This might help with the notoriously difficult problem of perceiving the real value of technology and computing devices as illustrated by the example of the unpredicted success of SMS (Stock 2002).

Sceptical views of the role of technology as overlooking the needs of humans quite rightly emphasise that Home is not a Machine – Home is for People. Home is not an array of tech-

nological tools that only help the residents lead and survive everyday life. Home is for humans, whose quality of life is expected to improve via technology and ambient intelligence. Home is an emotionally charged and personally furnished cradle of living – physical space as much as a socio-cultural context and a state of mind. From the user point of view, the technological applications have threefold implications: through them people get practical use, enjoyment and status. Enjoyment can be divided into different subcategories: playfulness, fun, aesthetics etc. In the late 1930s refrigerators were designed to appeal to an average homemaker both aesthetically and practically. In the late 1920s prestige and novelty were common themes in early refrigerator advertisements (Nickles 2002).

The application area is wide, since people spend more time in their homes than in any other space (Intille 2002). Home is concerned with people, spaces, rooms, artefacts, furniture, equipment, milieus and their various combinations in terms of time and space. There are four basic functions the housing application area will cover:

- Home Automation (Basic Housing Supporting Functions),
- Communication & Socialisation,,
- Rest & Relaxation, and Entertainment
- Work & Learning.

The home automation function covers basic housing supporting functions such as heating, plumbing, ventilation, air-conditioning (HPAC) as well as electrical and other installations. The Security function is analysed as another important area under home automation. Security has here different aspects: Security in terms of Physical Access Control and Burglary Alarm systems, Security in terms of health (prevention, monitoring), and Security in terms of safe construction (and materials). Home automation also covers the function of home control. Communication & Socialisation covers Inter-person communication and access to the Internet and to other information systems. Rest and relaxation is another very important basic element of everyday functions of home. Home can also be a place for hobbies. This part also covers the basic functions of refreshing up and maintenance of personal hygiene. Important part of rest and relaxation is entertainment. This part covers home electronics, Video, TV, Music, gaming etc entertainment. In addition to rest, relaxation and hobbies, the home is increasingly expected to provide premises for work and learning. The work done at home naturally includes household and maintenance work, but other professional work as well which normally is being done elsewhere (at office or with clients etc.).

The functions regulated and controlled by home automation are elements and functions of the house itself and its critical "living conditions" (housing infrastructure) as a basis for humans living in the house. They create the prerequisites for living in dwellings. The rest of the functions here dwelled upon are more centred on the residents themselves. They represent the functions people do more directly for themselves. In home automation the house itself is the major agent providing heating, lighting etc, while people moderate and control these functions. As regards other functions, people are major agents, while the house with its ambient intelligence provides optimal context for such activities. All the functions share as a common feature the purpose of responding to the users' needs and preferences in housing.

3.1.2 Home Automation

3.1.2.1 Basic housing supportive functions – HPAC, electrical and other installations

In home automation the main idea is to bring added value to the user by making the control of existing functionalities (e.g. HPAC, fire and burglary alarms, control of electronic appliances) easier, integrated and/or even automated. In user studies these kind of applications have been clear, and in fact proprietary solutions providing these applications are already existing on the market (Rentto et al. 2002).

Most of the functionalities of home automation system exist currently without any intelligence. The user may control lights or house warming with the existing switches and controls. In the home of the future, ambient intelligence enables controlling these functions through touch panels and eventually by voice, hand gestures, face expressions etc. The ambient intelligence here means that the home automation system identifies the resident and adjusts these functions according to the known preferences. The favourite kind of music or TV channel is automatically turned on, certain degree of lighting and heating is put on., window shades adjusted etc.

The functions controlling physical environment e.g. functions related to HPAC and security, have very high criteria for reliability and fault tolerance. The comfort of use is important but only secondary to these criteria. Hence, the system must be designed so that e.g. home server failure does not cause uncontrolled functions on these systems (Cluitmans et al. 2002). For instance, sudden turning off the lights in a cramped room may result in accidents.

A major challenge for ambient intelligence applications is to decide on whose preferences the functions are chosen in a shared space when more than one person is present. Even at the case of one person there should be enough intelligence to conclude e.g. from the facial expressions which kind of mood the resident is in at the moment.

3.1.2.2 Security

Security in the application area of Housing is divided into functions controlling through home automation the physical access and the health and wellbeing of the residents. Security also covers monitoring and controlling the "health" of the building itself (this can also be seen as part of the basic functions supportive functions). Security is based on using ICTs for maintaining various alarming systems (both for theft prevention and accidental events caused by the elderly, disabled, children, pets, wild animals etc.).

3.1.2.3 Physical Access Control

Physical access in houses today is controlled mostly with mechanical locks. More widespread use of electro-mechanical locks and doors makes digital access control viable. The access control can be then handled with electronic keys such as magnetic cards, RFID tokens or biometrics and the combination of these two. Biometric access control solutions are becoming

affordable also for private homes within five years. Most dominant biometric methods now are fingerprint and iris, while face recognition needs still maturing. Voice recognition offers natural interaction with the cost of lower security. The main challenges for biometric methods today are poor usability and public acceptance.

Two other aspects may be linked to physical access and biometrics,:

- surveillance with cameras and other sensors and
- use of biometric recognition in personalisation of the home services, e.g.
- choosing the right TV-channel and volume based on user's identity.

The locks capable of identifying persons and permitting hands-free opening would be useful for several population groups: elderly, children and disabled, as well as mothers entering home with both hands carrying shopping bags and guiding three children along.

3.1.2.4 Health care and Well-being

Healthcare and well-being (Wellness management) and support for independent living seem very promising applications for the smart home. They can be seen as part of the security function in home automation or they can be treated as a separate function (as in the Section 3.6).

First of all, there is a clear need to provide tools to support independent living especially for the elderly. These tools should include not only means to monitor health status, but also to compensate possible functional impairments (e.g. remote control of different electronics appliances and doors), add security (fire and burglary alarms forwarded to caregiver, automatic protection mechanisms for electronic appliances such as iron and oven), and provide improved communication means.

Hence, there is a need for several technical aids simultaneously, giving potential advantages for their integration into the same platform. Secondly, due to high costs of institutional living of these people, there would be a great motivation for society to support purchasing of this kind of systems if the evidence of prolonged independent living would be provided. Thirdly, especially in wellness monitoring, the expected operation is mainly invisible to the user (e.g. logging health data to the database). Single data items do not bear a great value (i.e. missing single measurement results is not a catastrophe, while missing a single fire alarm would be), and the long-term follow up brings real added value to the user (Cluitmans et al. 2002).

3.1.3 Communication

Home is a place for various types of communication (and socialisation), which function is given high priority in anticipations of the future home. ICTs facilitate communication at home, covering intra-person communication inside the home as well as to and from home, access to the Internet and to other information systems. The development of devices (esp. in computing) has moved from non-intelligent terminals to handheld and hands-free devices. On

one hand, sensing and interactive interfaces and on the other hand, user-friendly and compatible devices are needed. The developments will largely be driven by “what consumers will pay for” (Stock 2002).

Communication technologies support, facilitate and speed up communication, where socialisation is an integral part. It must be born in mind that communication and socialisation can also occur without any technological support at home.

3.1.3.1 Person to person communication

Fixed-line telephones/cordless phones have been the communication technology for decades already. In western countries practically all apartments and houses have a fixed-line telephone access point.

Cordless phones attached to a fixed-line network has been an enhancement of the telephone. Even though cordless phones have increased the mobility of telephone use, the paradigm of using the phone is still the same. “One-phone-line-for-one house”

Mobile phones have been a success story in communication technology. Simultaneously with increased penetration of mobile phones, communication between people has turned increasingly personal. Also Increased mobility of communication technology has added the availability of persons in all times: “Always Connected-paradigm”. This paradigm in private life has increased the quality of life and sense of security. However, as work has increasingly intruded to the home, the 24 h availability creates a great danger of stress and burn-out and the decrease in the quality of personal and family life as the cost of increased efficiency.

3.1.3.2 Person to community communication

Community communication (one-to-many, many-to-one) has been gaining momentum in the form of shared limited access web pages for families, hobby groups etc. It can be expected that this function will get also mobile realisations, where the sharing of community related content, such as family calendar, photos etc., will no more be limited by users location, PC access and computer literacy.

Person to community communication may attract applications of ambient intelligence for communication inside a family or household. For example, the home of ambient intelligence gives information on the whereabouts and messages of family members and pets for all, e.g. via flat displays on walls or on the common information "desk" – on the door of the refrigerator.

3.1.3.3 Internet

Since the early 1990's the number of Internet users has increased drastically. In the western countries Internet access point can be found basically in all homes/apartments. The access point can be realised either in Modem/telephone or xDLS-based technologies.

Broadband connections (xDSL-based technologies) have been increasingly popular. In many predictions it is stated that the price of broadband connections will be lowered considerably in the future. That will again increase the use of Internet in homes for various purposes (games, education, work) and at all hours of the day. At the moment, 54 % of the Finnish households, for example, has an Internet connection, of which 16 % is broadband connections (Sonera Internet Tracking 11/2002).

Home can also be perceived as a larger issue – as a node in home networking through the use of the Internet. As people can be connected via the Internet, so can the homes, too. Perhaps such ambient intelligence applications will be developed where houses can monitor other houses to increase safety, e.g. making an alarm when detecting a fire in a neighbouring house. This of course is a delicate topic touching on privacy and other related issues.

3.1.4 Rest, Relaxation, and Entertainment

Home is the basic place for resting and taking care of one's personal hygiene. Home is also a good place for relaxing and entertaining yourself, as well as doing hobbies. A hobby is an activity that you enjoy doing in your spare time. Many hobbies can be done at home, while many others are done outside the home. The same goes for relaxation and entertainment, whereas for the function of resting, home provides the primary location.

3.1.4.1 Rest & Relaxation

Sleeping can be considered as the most important form of the function of resting. People also spend 1/4 to 1/3 of a day in the bed. Quite little has been done in order to enhance the sleeping experience by means of technologies of ambient intelligence. Digital or electronic technologies introduced to enhance or help sleeping experience are ones to make you stop doing that. Such technology is for example digital alarm clock.

Some electrical inventions have been applied for helping sleepers. There are interesting visions from the 50's about peculiar electronic gadgets making bedroom electrically enhanced and also sleeping easy and enjoyable. Examples of this kind of applications are electrically heated and vibrating blankets or beds.

Visions presented 50 years ago are still viable. Of course, technology has developed and these applications can nowadays be built with more unobtrusive technology than earlier. "Smart" system controlling air conditioning, lights and temperature in the bedroom may still be a good application making rest more relaxing. There is a need for ambient intelligence applications providing more pleasant ways of waking up. A traditional not-so-intelligent device is a clock radio which has been set by a timer to give a soft wake up through radio voice or music. Perhaps some scents of favourite flowers, movements of the bed, or beautiful scenery projected on the wall or ceiling could also be integrated to such a "wake up call".

Sleeping usually takes place in the bedroom. Accordingly, the applications of ambient intelligence supporting sleeping can be focused on the process of sleep in its initial, midterm and terminal phase, embedded in clock, bed, lamp, window, floor etc. They can also be concen-

trated on connections inside the house, giving signals to other people in the house of sleeping persons in order to avoid disturbance. Besides sleeping, there are various degrees of rest such as drowsing. It can also be done in other rooms than bedroom alone – lying on the couch in front of TV may be one of the most popular places to take a nap. The weather permitting, resting can be situated on balconies or terraces in the garden. The function of resting may be supported by ambient intelligence applications such as sensors embedded into the furniture measuring the resident's pulse, blood pressure and suggesting different kinds of electronic massage or acupuncture. Such massaging armchairs have already been in the market for consumers for at least two decades. However, intelligence could be added in the form of (bio)sensors, identifying the person sitting and his or her wishes.

Relaxation could also be accomplished through several in-house hobbies. Ambient intelligence solutions could be developed to help and encourage hobbies. For example, devices turning home into a home theatre with sophisticated sound effects and possibly composing aids could support music as a hobby. Voice recognition could be combined with databases so that the dwellers can turn on the music simply by humming a few bars of a song (Peterson 2002). If literature is your favourite hobby, details of the novel you are reading could be retrieved via Internet and displayed on the wall screen alongside with some video clips of the author.

Physical exercise gives relaxation, even though it depends on the intensity it is made. If physical exercise is made very hard, it takes a lot of energy and can even make a person's muscle ache. If a moderate approach is taken, the result is overall relaxation. Accordingly, here is clear demand for ambient intelligence applications, which recognises and monitors the resident's state of health, need of physical exercise and remembers previous sessions, experiences and results, suggesting optimal procedures. Physical exercise can be made in space reserved especially for it, possibly using electronic exercise bikes or rowing machines. Another future solution might be to integrate physical exercise capacities into "ordinary" furniture, placed in living room, bedroom or even kitchen. This idea of multifunction, flexible furniture is already noteworthy (without any intelligence) in modern housing where the home is required to fulfil many functions in the same space (leisure, work, hobbies etc.). Ambient intelligence devices would monitor the resident if he/she wants to know e.g. the minutes used in stepping the stairs or walking inside the house and equivalent of consumed calories.

3.1.4.2 Refreshing/Hygiene

Another function closely related to rest and relaxation is concerned with the basic needs of the residents to refresh themselves and take care of their hygiene at home. This is an area where consumer electronics already abound. Ambient intelligence could be added to this array in the not-so-long-future. Bathing and showering space (tube, shower, sauna) could be equipped with ambient intelligence to identify the user and set the initial temperature of water, for instance, and play the background music expected. Tooth brushing, combing, shaving, making-up etc. normally takes place in the bathroom inside the mirror. Already at the experimentation level is a solution where the bathroom mirror not only reflects your image on its surface, but also the clock, news or the weather, or cartoons for the children. The same application can also display your weight and then report on your cardiovascular health, even giving advice on improvement (Peterson 2002). The idea of utilising the time consumed in the bathroom for

other functions as well is not a new one in itself. Many hotels already have loudspeakers in the bathroom so that residents can hear e.g. the news. Another thing is, whether it is safe to shave one's beard and watch the news. In analogy to combining car-driving and watching a screen (even if for navigation), your loss of concentration on the main thing may result in an accident.

3.1.4.3 Entertainment

Radio, TV and music records have been dominant entertainment technologies in home environment for decades. All of these technologies have been developed towards digital format. Music records are already now in digital (CD) and there are already digital radio and TV-channels. However analogue broadcasting is still dominant in both cases.

Music is currently purchased in CD-format and Video in DVD-format. Music CDs and DVDs are one of the most popular articles in Internet-based marketplaces. Ordering and payment of product is currently done in Internet. Only delivery of products still remains in the physical world. However, as the format of the content is digital, delivery via the Internet looks like a natural step to be taken.

Computer and console games have been an increasingly popular form of entertainment. Gaming industry is more closely related to other entertainment industry. There will be a computer game for most of the high profile movies and characters (e.g. Harry Potter).

Networking is an interesting aspect in gaming. There have been networked computer games for some time already. In the future we will see, if the same trend will take over in game consoles.

Mobile gaming is also an interesting trend. Earlier mobile gaming consoles were single game consoles, then they developed to mobile game platforms with possibility to have different games in memory card. Lately, gaming has become an important addition to functionality of mobile phones. There are even mobile terminals optimised in mobile gaming (e.g. Nokia N-gage).

Entertainment is handled in more detailed in elsewhere in this report covering also entertainment outside the home.

3.1.5 Work and Learning

The functions of work in its various forms in connection to housing (household, maintenance and home office work including telework or e-work) supported by ICTs and other new technologies is frequently addressed in the literature. The household work is primarily focused on maintaining and upgrading the welfare of occupants, and maintenance work aims at providing the living conditions adequate and comfortable in the premises – maintaining and upgrading the "welfare" of the building. However, hoffice work – abbreviation from home office work – has another role. It is a function that is usually done elsewhere outside of home, but is now integrated into housing. e-work is a function transferred by telepresence and concrete ICT

applications from elsewhere to be conducted at home, embedded among other functions of home. Home is also a place for learning. Children do their homework in their rooms or elsewhere in the home, but adult members of a household can also make some studies and need a place for learning. The topic of learning is dealt with in another review paper.

3.1.5.1 Household work

Household work is a basic function in housing. Household work is here perceived as a large domain, covering cleaning, laundry work, cooking and preparing meals, washing the dishes, and sewing etc. – all basic activities keeping the house as a comfortable place to live in. Cleaning the house could be facilitated by more efficient vacuum cleaners and eventually cleaning robots with sensors for turning when facing obstacles. Ambient intelligence would be needed for the cleaning robots to discern small items on the floor and to tell the difference between a trash such as a bottle cap and valuables such as a diamond ring, for instance. Ambient intelligence will proceed when self-cleaning surfaces can be integrated in the house. Then the cleaning equipment will disappear and the cleaning function will be embedded directly to the objects to be cleaned as their own intrinsic properties. Washing machines form the main technological tools for cleaning and taking care of clothes and all kinds of linen used in housing. Other related machines are drying machines, sewing machines etc. Today, they already contain microprocessors and a variety of programmes. Ambient intelligence could mean that the machines themselves could conclude from the degree of dirtiness the need for a certain programme, e.g. in a washing machine.

Cooking and preparing meals is a function that is at the same time on one hand very basic and routine and on the other hand a very social happening – a process involving socialisation with family, friends and relatives. The process begins with preparing the meal, having the meal and cleaning up. Ambient intelligence could be applied to establishing a database of guests' food preferences, allergies, previous caterings etc., suggesting menus. In cooking, the oven could become aware of the degree and need of cooking time for a given portion of food and regulate its heat. This, however, is not a very likely property to be developed. In robotics, prototypes of serving robots, pouring drinks for example have been developed. However, this is a delicate area where people prefer human encounter - technology should be invisible. Tables could have surfaces which know which dishes have to be kept warm or cold. The kitchen is already now the heart of home, in a sense that life-sustaining food preparation takes place there. In addition, it is a communication centre where the refrigerator wall often abounds in notes from family members (shopping lists, messages and appointments). The refrigerator could become a kitchen computer displaying information and evaluating its own contents and missing ingredients. Such technological developments are already under way.

Another major field is work aimed at taking care of the residents - child care, elderly care, disabled care as well as taking care of thefts. Applications of ambient intelligence could be connected to monitoring the safety, health, location and needs of people. Here again, fears for technology substituting human touch are eminent.

Also gardening can be included in household work covering the work just outside the house. Increasingly the houses are also equipped with green houses.

3.1.5.2 Maintenance work

In analogy with future applications of ambient intelligence in the form of self-cleaning surface, self-repairing elements of the house could be developed. Walls, floor and the ceiling could monitor themselves and start repairing themselves or at least warn about the situation. When painting on the surfaces wears off, it could be replenished. Lawn mowing robot has already been developed. What would then make such household robots more developed towards ambient intelligence? Perhaps the capacity to detect a need for lawn mowing would be such. In the far future still lies the prototype of a lawnmower which would detect flowers to be preserved on its working area.

Changes in weather conditions may be a trigger to activate certain maintenance functions in the house. For example rain together with temperature close to freezing point may activate a doorstep heater outside the house.

3.1.5.3 Home office work

Home is increasingly a place for some work to be done therein. Usually the work is done in a fixed space inside the house, but transferable in time into other locations inside home. This space can be called a "hoffice" – home with an embedded office. Such work can be for example home-based overtime work – people taking work from office home with them to be done in the evening. Work could be altogether located at home – such is free-lancer or subcontracted work. The work could be knowledge work involving a variety of ICT equipment and installations. Work could be any other work as well, a common denominator is that the work requires space and equipment. Housing makes its own demands on this function. The work space should be flexible, convertible and not-much-space-consuming. The computers will have to move from the desk to the wall and be equipped with speech-recognition technology. This applies not just to home-located work, but to all other functions as well. Halal (2003) calls this new conversational human-machine dialogue as TeleLiving. The division between work and leisure has been blurred. However, there is a growing demand of keeping these two functions apart, while enabling them both at the same place (home). This is because work located inside the home may cause unnecessary stress by the simple visual existence of the hoffice. Applications of ambient intelligence could be integrated into the furniture and walls. Another category of work done at home is e-work. Telework or e-work is characterised as work substituting the work done at office. Thus, overtime work is not telework, although the nature of carrying out the work is the same. Space for e-work has certain requirements and especially the ICT equipment and installations need to be located with a minimum hindrance to daily routines in housing. The space, furniture and installations for e-work are suitable for all the other teleactivities as well. Therefore, there is a demand for applying ambient intelligence to make such space and work functions as comfortable and discrete as possible.

3.1.6 Acceptance Factors

The idea of home equipped with technical burden-reducing and life-enhancing devices is an old one. What is new in this idea is the added value of the transparency and interactivity of ambient intelligence. As Marzano puts it, paradoxically the home of tomorrow will look more

like the home of yesterday than the home of today (Marzano 2002). The bulky technological devices will fade into the background and be embedded into surfaces and ornaments.

There are great opportunities for ambient intelligence in housing: people spend much time in their homes, societal development and trends in lifestyle have broadened up the scope of activities located at home. Similar solutions as already developed for cars can be applied in housing as well. Consumer electronics is the pioneer family of products, having already gained a strong foothold in housing, and to be developed in the forefront towards ambient intelligence.

However, there are some critical aspects and serious challenges concerning the development of ambient intelligence in the field of housing. Home is a sanctuary, so technology and technological devices integrated to the house should not dominate the overall function of housing. The technology should enhance the quality of life of residents, not only by facilitating their daily activities, but also supporting their socialisation. Another major challenge for ambient intelligence is how to make technology learn about the people and their identity: habits, preferences, behavioural patterns etc. and how to apply such knowledge in varying contexts. Such situational awareness should be promoted simultaneously securing a sufficient degree of privacy and prevention against misuse. The more complex the systems become, the more vulnerable they are to malfunction.

Finally, there is also an ethical and a philosophical issue involved. Applications of ambient intelligence in housing should not automate the home to the utmost. If initiative or physical movement is no longer needed, the 'passivating' implications for the elderly, especially, might prove deteriorating to one's physical and mental health. Moreover, if the prices of ambient intelligence are high, there is also a risk of excluding average people. The ultimate challenge is to promote ambient intelligence in balance with producing a high quality technological system of "housing-aids" and providing enough safety, stimulation and socialisation.

3.2 Mobility and Transport

3.2.1 Introduction

Based on the analysis of seminal studies on the future of mobility/transportation and on Ambient Intelligence respectively this study will describe the contexts of use and the specific social categories are of importance in order to assess how AmI might be used in the traffic and mobility application area and its application sub-areas Traffic Management, Navigation, Safety, and Mobile Information and Entertainment. Furthermore some indications of the impact of the drivers on the use of AmI solutions will be given (See Hightech Report 2000ff; Krueger and Gessner 2001 and 2002).

The analysis will be limited to public and private ground transportation, since these are the most important modes of transportation in everyday life. There are however numerous applications of AmI technologies in air and sea transportation as well as in logistics.

The state of the art in transportation engineering has advanced dramatically over the last decade, and the application of new and more flexible traffic control devices, software systems, computer hardware, communications and surveillance technologies, and analysis methods has become commonplace. The use of AmI technologies will further advance these developments in the next decade. Metropolitan areas will create or expand *traffic management* centres that monitor and manage traffic flow on streets and freeways using numerous real-time data sources ranging from traditional closed-circuit television cameras and fixed traffic and weather sensors to the information that is recorded by “intelligent cars” and submitted over mobile and ad-hoc networks respectively. Travellers will be informed of possible problems via a Personal Information Assistant or a Car Navigation System. Public authorities and private transportation providers will be the driving forces with traffic management systems, though they will rely on the co-operation of the automotive industry that must equip their car with systems that are compatible with the traffic management systems and provide the necessary information.

While traffic management systems address the need of an efficient control of the traffic flow, *Navigation Systems* are directed towards an efficient support of individual travellers. This does not only include the provision of information about the shortest possible routes, the actual traffic situation and alternative routes. AmI technologies will also address the need for dynamic routing depending on information from traffic management centres and from other travellers. In combination with context information and personal profiles navigation can become more intelligent (e.g. navigation to the next restaurant matching the travellers personal preference instead of travelling to an explicit address). In the sub field of navigation the automotive industry has been for a long time in past and will also remain the driving force.

Safety is directed towards reducing the risks of traffic. The enhancement of traffic safety has been a goal of public authorities and the automotive industry for a long time. ICT has become an important factor in this endeavour during the last few years. In the near future the combination of data from numerous sensors measuring the condition and behaviour of the car and the driver will make it possible to identify risks and propose and/or initiate countermeasures. Therefore public authorities and the automotive industries are the most important actors on the supply side. On the user side new safety features normally are built into upper class models. As costs of safety applications fall they will become commonplace in every car. For mobility other than by car safety applications have to be included in smart textiles. The sports and leisure industry will be a driving force addressing the need of special target groups such as youngsters. Safety in cars and especially the reduction of serious and fatal injuries has been and continues to be of great concern to Governments. State legislations have passed a number of traffic safety laws to enforce the use of equipment to increase traffic safety. Examples are laws passed that require installation and actual use of safety belts and head rests. Public authorities thus could deliver the decisive push for the development, installation, and use of intelligent safety devices.

The general trend towards *mobile information and entertainment* will strongly affect the use of AmI technologies for traffic and mobility applications. Car manufacturers are trying to offer all information services available over the Internet as well as entertainment offers in the car environment as well. Combined with context information new location based services will emerge which will be important for other application areas as well. The main technical challenges lie in the provision of adequate bandwidth and the design of a suitable user interface. The main actors in this sub field are currently the automotive in collaboration with the consumer electronics industry. However the success of this field will depend on external network effect, which relies on the existence of a variety of specialised service and entertainment providers.

The relevant and resulting functions within the mobility and transportation area are listed and described. As a next step, a number of existing and emerging ambient intelligence solutions are indicated.

3.2.2 Management of Multi-Modal Traffic Systems

Better utilisation of existing transportation means is considered an important way to contribute to a better environment. One way to achieve this is to co-ordinate the mix of transportation modes available. Public transportation combined with individual transportation can provide a more efficient way of moving great numbers of people in urban and metropolitan areas. Integrated traffic management systems will become increasingly important to handle the growing volume of traffic and prevent a potential traffic infarct as well as reducing the environmental burden. AmI technologies will play an essential role in vehicles and wearable devices to provide data for advanced integrated traffic management systems. However protection of the environment and more efficient use of traffic infrastructure are often contrary goals.

Multi-modal traffic systems have been internationally the topic of a number of research and pilot projects including such EC supported projects as ENTERPRICE, INFOTEN, and CAPITALS.

Table 2: Structure of the Mobility Application Area

Goal	Sphere of usage	User	Provider
Traffic Management			
<ul style="list-style-type: none"> Better usage of existing traffic infrastructure Conservation of the Environment 	<ul style="list-style-type: none"> Public Sphere: e.g. Management of traffic systems, Traffic prediction, dynamic monitoring and routing of traffic Commercial Sphere: e.g. efficient provision of transportation means; travelling without ticket 	<ul style="list-style-type: none"> General public especially “commuters” and intramodal traffic users 	<ul style="list-style-type: none"> Public Authorities Transportation Carriers Service Providers ICT industry
Navigation			
<ul style="list-style-type: none"> Reaching the destination in the fastest and most convenient way Seamless change of transportation means 	<ul style="list-style-type: none"> Private and Public Sphere: General Traffic Information and individual navigation support Public Sphere: Travel Assistance, Navigation of individual vehicles and persons 	<ul style="list-style-type: none"> General Public 	<ul style="list-style-type: none"> Automotive Industry Public Authorities Transportation Carriers Service Providers ICT industry
Safety			
<ul style="list-style-type: none"> Reduce the risk of traffic accidents 	<ul style="list-style-type: none"> Public Sphere: Driver Surveillance (stress, fatigue, dugs), vehicle and environment monitoring 	<ul style="list-style-type: none"> General public Privileged groups: professional drivers Risk groups (chronically ill, young drivers) 	<ul style="list-style-type: none"> Public Authorities Automotive Industry Textile Industry Sports article/leisure industry ICT industry
Mobile Info- and Entertainment			
<ul style="list-style-type: none"> Informing about the environment of a person, especially about mobility options Entertainment and information access where possible and necessary 	<ul style="list-style-type: none"> Every Sphere: Personal Information Assistant Public and private sphere: location dependant communication Commercial Sphere: Multimedia Car 	<ul style="list-style-type: none"> General public, Special target groups (tourists, business travellers, etc.) 	<ul style="list-style-type: none"> Content Provider; Entertainment Industry/ Media Service Provider Semi-Public Authorities (tourist offices) ICT industry

3.2.2.1 Traffic Monitoring

Large cities and metropolitan areas throughout Europe and other industrialised countries rely on IT-Systems to survey and monitor their traffic. The available information relies predominantly on stationary sensors such as inductance loop detectors buried at traffic intersections or certain traffic lanes or video cameras stationed at neuralgic traffic spots. Traffic information

provided by moving sources such as traffic police helicopters and more recently also from private travellers via mobile telephones is usually qualitative and of limited use.

New sources for reliable, precise and up-to-date data on traffic conditions will be possible through advanced concepts such as 'networked traffic' and 'floating cars' utilising sensors and ICT in networked cars (Siemens VDO 2002; BMW AG 1999). AmI technologies such as wearable ICT could extend this concept to public transportation. An exact and up-to-date monitoring of surface traffic will thus be possible.

With smart clothing or simple tags carried by travellers and suitable sensors installed at strategic locations movement of pedestrians and users of public transportation can be recorded. Immediate and short-term demand for public transportation could thus be determined and subsequently managed to provide for appropriate transportation customised for the real need.

Examples:

- Cars, buses, trams, etc. will be fitted with sensors, computational systems, and transmission devices for automatic transmission of traffic data.
- Suitable electronic tags worn by travellers for anonymous registration and counting.
- AmI in clothing would automatically transmit current position, destination, and travel mode of travellers.
- Electronic sensors with computational capacity placed at access points for public transportation.
- Automatic counting of the number of people waiting at stations.
- Cars automatically transmit their own position, direction, speed, environment, and destination to central traffic management.
- Vehicles will be able to exchange critical information directly and together with central information systems form a traffic information network.

Trend breaks could be caused by the privacy issues, which would be violated by monitoring spatial positions and movement of individuals and uncontrolled exchange of information or traffic networking.

3.2.2.2 Dynamic Routing

Employing electronic traffic guidance systems traffic can be routed for undisturbed flow. This can be done via strategically located electronic boards or using mobile communication. A more direct way would be to broadcast the relevant information to mobile navigation systems used in cars or to PDAs in case of pedestrians. Once notified these systems could automatically compute alternate routes and thus navigate their user around a trouble spot.

Traffic prediction will contribute significantly to intelligent dynamic routing. Today traffic prediction is relying heavily on past data. Thus early predictions about traffic flow on holidays or at the start of vacation times cannot account for situations occurring hours or minutes before the actual start of a trip. With more accurate real-time data on all modes of traffic utilising methods described above, short term predictions will become more precise and situation relevant and consequently more reliable. It will be possible to inform travellers in time and

suggest alternate routes or transportation means. Traffic congestions could be avoided or at least minimised.

Dynamic routing could also be applied to public transport systems by notifying potential travellers via mobile devices about short time changes in schedule or unavailability of seats. Some city and metropolitan transport authorities already provide real-time information on bus and tram arriving times using electronic boards at access points today.

Examples:

- When approaching a problem area drivers will receive automatic broadcasts with precise and up-to-date directions to navigate around a problem spot.
- Current departure and possible delay times of public transportation with alternatives will be broadcast to travellers who have registered their access point (station), desired time of departure and destination.
- Vehicles headed for over-crowded parking facilities will be automatically re-routed to either free spaces in the immediate vicinity or to a park-and-ride parking area.
- Spontaneously arranged activities such as demonstrations will immediately be reflected in the predicted traffic flow and passed on to the user.
- Emergency construction work such as broken pipelines will provide input to the prediction system and a re-routing determined.
- A slow down of traffic automatically reported by cars involved at the scene will cause prediction of potential traffic congestion and deduce alternate routes to take.

3.2.2.3 Ticketing and Control

Ticketing and control of valid tickets is a problem, which not only means financial losses to the service providers but can also be a cause of traffic delays and annoyance for the travellers. Automatic toll collection systems, like EZ Pass⁴ are keeping traffic moving at toll stations without the otherwise necessary stops. AmI technologies could be used for keeping track of persons using public transportation making sure that they are only charged for the service used. This would minimise the financial losses of public transportation provides due to fare dodgers or joy riders. A ticket-less system thus will be of great benefit to the service provider but in the transition phase will cause significant inconvenience to travellers when using a. o. foreign public transportation.

Examples:

- Electronic ticketing using a cash card when entering a bus, tram or train.
- One form of mobile payment currently tested for buses could also be used for trams and trains. Passengers can request an SMS-Ticket using their mobile phone.
- Suitable (passive or active) identification tags worn by persons entering public transportation with automated central billing.

4 EZ Pass is an electronic toll collection system used at tollbooths by the U.S. States New York, New Jersey, and Philadelphia. A receiving antenna reads the account information on an electronic tag installed in a car while passing the toll plaza.

- An integrated ticket-less system to support the use of multi-modal transportation.

A general problem of cash-less payment is the dependence on world-wide standards. The widespread use of credit and electronic cash cards has not replaced but complemented the general use of cash. Ticket-less public transportation will at first only be possible as an addition to current ticketing. However, with general use of smart cards, micro-payment systems, and international standardisation tickets may become obsolete in the future. Trend break could occur due to the distrust of persons to monitoring of their movements and to be charged for services without immediate feedback.

3.2.3 Navigation

The requirements for mobility continue to increase at a rapid pace. Across national borders road traffic is still growing all over Europe demanding more sophisticated and universal vehicle guidance and navigation systems. Car navigation systems have become affordable for a significant portion of the driving community. Navigation systems can also be of benefit to personal mobility. Today navigation relies heavily on satellite positioning systems. The U.S. Global positioning System (GPS) is currently in world-wide use. In March 2002, the Council of the European Union decided to set up the civil European satellite navigation system Galileo. It should offer fully operational capability starting 2008.

Traffic information especially concerning traffic flow and accident reports is mainly broadcast on radio. Although instructions on how to bypass congestions i.e. what alternate routes to take are often also supplied, in many cases this information lacks actuality and leads to additional bottlenecks on the recommended detours. Real-time navigation depends on real-time traffic information as well as road and weather conditions in order to effectively assure free-flowing traffic and movement of persons and goods.

3.2.3.1 Real-Time Traffic Information

Today traffic information systems are not being used efficiently. For one they do not reach all travellers and on the other hand they lack up-to-date information. The latter is one of the reasons that not all travellers make use of this service. Although some efforts have been put into improving the situation traffic congestions continue to cause large time delays, irritations and financial losses. In some cities traffic guidance systems have been installed. Using electronically controlled displays these systems aim to control the speed limit (to regulate traffic flow) and traffic signals and to provide information on available parking spaces.

More and better sensors strategically placed at traffic bottlenecks coupled with direct feedback on traffic conditions from travellers via mobile telecommunication and ad-hoc networks will provide for real-time and reliable information on traffic flow, traffic volume, and actual or anticipated congestions.

Information on road conditions (e.g. road construction, road surface condition) and current and expected weather conditions will be directly transmitted to the travellers in a form appro-

priate for the mode of transportation. Information will be spread either as broadcast (push) with regional orientation or by demand (pull) initiated by the user.

Examples

- Remotely controlled sensors placed above the ground with wireless transmission of data will provide real-time traffic information.
- Information on available parking space will become available in real-time.
- Disabled or even elderly persons will receive instructions and guidance in for them suitable form to improve their orientation.
- Participating vehicles will transmit information on traffic, road conditions, and weather to a central information server.
- High-bandwidth networks will run along the sides of roadways linked to communication and navigation systems in vehicles.
- Real-time traffic and weather information will be stronger localised. A continuous monitoring of air temperatures measured by moving cars will provide for in-time warnings of possible icy surfaces.
- Traffic information on multi-modal travel will be made available as personalised e-mail services, mobile phone service, and digital radio.
- Information on slippery roads due to oils spills or water will be immediately processed and respective warnings of impeding slow-downs and delays issued to drivers in the area and those headed in the affected direction.

Lack of funds available to local traffic authorities could delay the installation of an infrastructure necessary for new navigation services.

3.2.3.2 Travel Assistance

Localised travel assistance is considered to become part of the location-based services currently being implemented by mobile telephone added service providers. Using AmI technologies this information which includes information within a local area on such things as nearest train station, taxi, ticket vendor, porter service, booking office, hotels, restaurants, etc., could be augmented with real-time traffic information, availability of alternative transportation, time tables and delays, as well as navigational support (Bauer and Berger 2001).

Examples:

- Up-to-date timetables on all public transportation will be easily accessible. Any delays or short-term changes will be flagged.
- Ad-hoc arrangement of car sharing to prevent traffic congestion.
- Built-in navigation system will be synchronised with real-time traffic, weather, and road conditions.
- Real-time reservation of guaranteed parking space will be possible using the on-board communication and navigation system, avoiding at the same time unwanted 'search traffic' in city centres.
- Car information and navigation systems will be designed to minimise driver distraction (see also section on safety)
- Navigation systems will automatically download latest information from servers.

- New integrated car information systems will provide for navigation, information, communication, and entertainment (see also section on mobile information and entertainment)
- Wearable AmI will enable pedestrians and travellers using multi-modal transportation to access and benefit from all available services.

3.2.3.3 Individual Navigation

Individual navigation will not only be available while driving a car but with AmI technologies pedestrians and travellers using public transportation will also be assisted. Already today navigation systems based on GPS can be used on PDAs equipped with GPS receivers. Increasing memory capacities of compact size can provide for static information such as street maps, which then can be used together with the location identified via GPS. Although navigation systems have decreased in cost, the devices required for their use are not yet widely diffused. In the future navigation will be more customised to include individual preferences and current status of the traveller and the environment.

Examples:

- Car navigation will monitor current status of the vehicle (current speed, position, fuel left, etc.) and the driver (hours on the road, stops taken, eye movement, etc.) to determine the best route to be taken.
- General navigation will be localised with current information on weather and road conditions, dangerous crossings or turns, as well as the real-time traffic on the route ahead.
- Alternative directions to circumvent congestions and other road hazards on the route currently taken will be recommended in real-time.
- Public transportation users will be informed in real-time on arrival times, delays, time left till destination, transfer point, waiting time.
- With real-time information always available on time schedule, pickup points, destination, and free space, car sharing will become attractive.
- With the expanded capabilities the interfacing to navigation and information systems will especially in the car need to be reconsidered to avoid unwanted distraction of the driver.

Trend breaks could be caused by prices for individualised systems being too high and thus not affordable by a large enough population to pay for the investments necessary.

The general question as to who will pay for advanced traffic and information services still exists. Communities and public authorities will have to provide the infrastructure. Public-Private partnerships with service and content providers will be necessary to make the overall system possible.

3.2.4 Safety

The car will remain the most important traffic means in everyday life for the next years. The increase of car safety is therefore one of the most important needs to be addressed by AmI technologies. In comparison to other fields of application the car has better prerequisites with respect to the available space and energy. Hence it is difficult to distinguish between “tradi-

tional” car electronics and AmI applications. The distinctive feature, however, will be the awareness of the car of its environment and its driver’s behaviour.

In the literature the development of AmI applications has the goal to reduce the various risks associated with traffic and to build accident-free motorway-cars. Car manufacturers are trying to reach this goal within the next decade.

3.2.4.1 Driver Surveillance

A majority of accidents especially rear-end crashes are caused by driver inattention and following too closely. The inattention of the driver may be caused by a variety of reasons – driver fatigue, stress and the misuse of drugs being the most prominent. Ambient Intelligence Technologies offer the opportunity to monitor the driver’s physical condition, diagnose signs of incapability to drive, warn the driver and intelligently influence his behaviour. An automatic intervention is only the final and not necessarily the most suitable action of this kind of AmI application (Healey et al. 1999; Pompei et al. 2002). A form of intervention which could possibly be enforced by safety laws would be the externally initiated reduction of driving speed in case of hazardous driving or bad road conditions.

Examples:

- Body sensors measuring blood pressure, skin conductivity or certain substance in the exudations of the driver (e. g. alcohol, drugs),
- Sensors in the steering wheel or gear lever measuring the same parameters as above,
- Video sensors monitoring the driver’s eye movements, blink duration and frequency in order to recognise indirectly the degree of alertness, stress or distraction,
- A combination with a navigation system can lead to a profile of the kinds of traffic situations raising (or lowering) the driver’s stress level.

An important limiting factor may be the reluctance of the driver to external control. The service must be robust enough to be tolerant to unusual but not hazardous driver behaviour (otherwise it will be turned off).

3.2.4.2 Vehicle and Environment Surveillance

Besides the driver there are a variety of external factors that are the source of fatalities. In order to reduce them AmI can be interpreted as a car knowing its own condition and its environment. In the literature three different sources of information for the “knowing car” are addressed: (1) information about the car, (2) information concerning the environment of the car, especially obstacles crossing the car’s trajectory and (3) additional data delivered through communication services. This data can be used for different applications aiming at an increased safety (Chatard et al. 2002; Langheim 2002).

Examples:

- Detection of lane markings and obstacles (different solutions using Radar, Laser Scanning, passive light wave technologies),
- Detection of technical defects (air pressure in tyres, level of oil and coolant, status of brakes),

- Detection of traffic lights and warning signs,
- Detection of hazardous environmental conditions (slipperiness, limited visibility),
- In each case possible warning of the driver or automatic intervention. An integration of active and passive safety systems with a driver assistance system is pursued.

Safety applications for other vehicles than cars are having more restrictions with respect of available space and energy, while especially for motorcyclists a surveillance of speed, road curvature in relation to the existing friction are additional tasks. Here smart clothing solutions are needed.

With respect to data in- and output AmI technology for motorcyclists is much more demanding (noise level, little space for displays and the limited possibilities for manual input being the most important factors)

An important limiting factor may be the reluctance of the driver to external control over the car.

Technologically the prerequisites for safety applications are: (1) Affordable sensor technology (sensors have reached an enabling level today) (2) Ubiquitous embedded computing (3) Networking through wireless and wired channels (communication technology have reached an enabling level today). But so far, size, reliability, and cost do not match automotive needs.

3.2.5 Mobile Information and Entertainment

By their very nature, ICTs are suitable for people to receive or request additional information on traffic and mobility matters. This area considers peer-to-peer services, pull services as well as push services (one-to-many). AmI provides the opportunities to further personalise information and to make it contextually and action dependent.

Almost all car manufacturers and automotive suppliers have made several studies on multimedia systems over the last few years (e.g. DaimlerChrysler, BMW, Fiat). It is expected that within the next decade driver information systems will not only provide navigation aids but also integrate functionalities in the areas of entertainment, information and telecommunications for the driver and other passengers. Public transportation providers have also started to equip their vehicles with the infrastructure necessary for mobile information and entertainment (e.g. Railway, Airlines).

3.2.5.1 Information

Traffic and mobility is a central human need but takes up a lot of time in everyday life. During that period the traveller/driver should have access to all information he needs in the same way as one has in the office or at home. Moreover the combination of information available in different sources (Internet, appointment calendar, etc.) with information about the traffic and vehicle situation can give added value to every traveller.

Examples:

- Connect information from other areas of the user's life with mobility information (e.g. connecting calendar and traffic status -> initiating actions and communication)
- Enable different modes of communication in a seamless way (e.g. reception of email with speech output)
- Give information about accommodation, restaurants etc. along the travel route
- Access to the internet/appropriate presentation of contents
- Remote control of the car from a mobile device (e.g. request of position, request and change condition of door and window locks, switching of the stand heater)
- Automatic contact of emergency services, reporting vehicle location and damage

However, mobile use of information inside a vehicle is different from the way it is used in the office or at home. In a vehicle, the main task still is and definitely will be driving, although the driver may change from "in command" to "in control". That means that only limited mental and visual capacities are available for using information equipment, especially those that have nothing to do with the main task. Moreover many traffic situations do not allow attention anywhere other than on the traffic, leading to strict time restrictions.

3.2.5.2 Entertainment

Passengers of a car will have all the possibilities of entertainment that are also available at home. In a limited sense this will be true for the driver of the car as well.

Examples:

- Individual terminals next to the seats for interacting with the Internet, watching TV and DVD video, playing computer games. The displays will be flexible and can be pulled down within the car offering flexible viewing options. These screens can be used as personal space dividers: for example, the children can study or watch cartoons in the back without disturbing the parents in the front.

Open and flexible standard needed due to different innovation characteristic in car and IC technologies. Long development and utilisation periods mean that vehicle systems become outdated very quickly.

The main problem of a high-quality Internet access is the limited bandwidth of cellular networks (even 3G when the user is moving fast) and the small displays that can be used in cars.

3.3 Shopping and Commerce⁵

3.3.1 Introduction

The state of art in commerce has changed dramatically in the last few years, due to the coming of electronic business and electronic commerce, which are not only undoubtedly changing shopping traditional habits, but also imply (and more and more will imply) an evolution in retailing and logistic transactions. Electronic business (e-business) is any process that a business organisation conducts over a computer-mediated network. Business organisations include any for-profit, governmental, or non-profit entity. Their processes include production-, customer-, and internal or management-focused business processes. Electronic commerce (e-commerce) is any transaction completed over a computer-mediated network that involves the transfer of ownership or rights to use goods or services. Transactions occur within selected e-business processes (e.g., selling process) and are "completed" when agreement is reached between the buyer and seller to transfer the ownership or rights to use goods or services.

Beyond e-business and e-commerce, a number of trends have emerged in technology and in the ways in which technology is deployed in the field of Ambient Intelligence related applications. These trends represent remarkable new opportunities for the development of new functions and services, especially in the area of marketing and advertising. The new ICT tools for doing commerce require an increase of the level of performance in the physical distribution of goods; also in the field of logistics ICTs can provide opportunities for development. These trends involve:

- mobile commerce,
- voice technologies,
- DAM (Digital Asset Management) and DRM (Digital Rights Management).

For each of these topics, we'll define the value chain, in order to identify the emerging trends and to highlight its socio-economic relevance.

In this section, we describe the most relevant functions and services within the commerce and shopping area, highlighting the emerging Ambient Intelligence trends and applications.

3.3.2 E-business and E-commerce

Currently, e-business and web commerce applications are focused on commerce components aiming at making available a broad subset of user-friendly, efficient and distributed service support to the customer, such as creating and managing a web storefront, presenting it in the

⁵ This section is based mainly on the following sources: Forfas 2002; PWC 2002; Ffoulkes-Jones 2002; Yaffe 2002; Jalali-Sohi and Baskaya 2001; NISTEP 2001; UK Foresight Program 2002a, 2002b; CRIC 1999a, 1999b; McMeekin 2000; Chakraborty and Chen 2002; Norén 2002.

familiar catalogue mode, managing the search for and selection of merchandise by the customer, and handling order and payment processes.

A commerce transaction covers a complex range of activities from the moment a customer enters the site to product selection, purchase, billing, shipping, and possible return of merchandise. The main services provided to a customer are the following:

Catalogue services: they enable the creation and management of the product catalogue, which typically resides in an external database. These services include the search functionality that web-site visitors use to locate the desired merchandise.

Shopping cart: it enables shoppers at the site for select items for purchase. It may include a gift registry, wish or purchase lists, and has the ability to save a record of shopping cart contents between visits.

Marketing & advertising: allows content personalization for shoppers, merchandising, and campaign management. It may include functions such as recommendations for up-selling and cross-selling, customised pricing, discounts and coupons.

Order processing: it manages payment processing, including tax calculation and credit card transactions. It also includes functions such as customer's address management, discount and coupon application, and inventory processing.

Configurator: firms use configurator applications, also called configurators, to speed the selling process, reduce errors in orders, and replace person-to-person selling with customer self-service.

Personalization: personalization is the ability to track customers and respond to them by drawing on knowledge of their current and past contacts, interests, and behaviour.

Above all these application, we can find a pervasive and enabling function: the security of electronic transactions and the protection of personal information.

3.3.2.1 Catalogue Services

The catalogue works as a central repository for the web store's product information. Most e-commerce sites employ more than one product catalogue. The product data in a catalogue typically include the full name of the product, a description, information about price, weight and size (which may be used to calculate shipping charges), a photo, inventory information, and any technical specifications the seller deems appropriate. Product data also can specify which products to use for up-selling, cross-selling, and substitutions. Catalogues differ according to their data requirements. A clothing retailer may require many image fields for photographs of its merchandise; a chemical vendor and its customers may require in-depth, directory-style listings.

A very important part of catalogue functionality is the search mechanism. It enables customers to search for the products in which they are interested, causing the catalogue to query the

product database and withdraw information from it, which the catalogue then formats and presents to the site visitor. Search functionality is vital because the inability to find a particular product is one of the main causes of dissatisfaction among web shoppers: the high rate of shopping cart abandonment is often attributed to it. Catalogues typically enable site visitors to conduct different types of search, including key word, full-text, and parametric.

Site shoppers do not often rely on search techniques only to find what they are looking for in a catalogue. On the contrary, they navigate through merchandise by browsing through a hierarchy of groupings and subgroupings. During catalogue set-up, the administrator defines the relationships among various groups of items. A clothing retailer's site, for example, might include a merchandise classification such as "Women Apparel". Within a grouping there are appropriate categories, such as Pants, Shirts, and Accessories, which may contain their own subcategories: for example, Denim, Casual, and Slacks. An individual catalogue item can be classified in multiple categories: for example, a pair of fashion jeans may appear in both the Denim and the Casual categories. By clicking on the different links in a hierarchy, a shopper can navigate through successive web pages to find the designed items. The relationship that a company establishes among its catalogue items also can include the grouping of items into product bundles or packages.

3.3.2.2 Shopping Cart

The shopping cart enables the familiar process of a customer placing items into a virtual holding place (the shopping cart) until they are ready to be paid for through the order processing module. Generally, a shopping cart icon with the total number of items in the cart and the total money amount of the order is visible while the shopper browses the site. The shopper can click on the icon to go to a summary page to review items in the cart, remove or add items, and change the number of items ordered. Items are maintained in the shopping cart during a single shopping session by using encoded Universal Resource Locator (URL) listings or cookies.

Almost all web sites save user profiles, which include shipping and billing information, preferences such as desired delivery method, and order history. All customer data are protected through a user authorisation procedure, which requires that the user initially registers at the site and chooses a password.

More advanced shopping cart functionality provides features such as wish lists, gift registries, and persistent shopping carts that retain their contents if a visitor leaves the website and returns later. This shopping cart information is stored with a registered users profile, which resides in the customer database. Typically, items left in this persistent shopping cart are purged from the cart after a given period, often 30 or 90 days.

Once the shopper has made the final selection, he or she goes through a checkout process, reviewing and confirming the order, then submitting the required payment and shopping information. Typically, the process guides the shopper through a series of screens to complete the purchase process.

3.3.2.3 Marketing and Advertising

Marketing activities are an important component of the commerce server. These features include product merchandising, personalization, and advertising campaign management.

Many web commerce components sites allow personalization of content, which matches customer attributes, including demographic information and buying behaviour, with content attributes by using rules or algorithms. This tactic is based on the assumption that the more targeted a product recommendation is, the more likely it is to be of interest to the shopper, and the more likely a sale will occur.

Shopping recommendations can best be seen at Amazon.com, which uses a technique called collaborative filtering. Repeat customers are offered recommendations for products that have been purchased by others, whose profile or order history are similar. Customers who do not like the products recommended by the site are encouraged to customise the site's recommendations through a manual rating process.

In addition to collaborative filtering, basic up-selling and cross-selling features are usually provided. These merchandising activities usually occur immediately after an item has been placed in the shopping cart, although some catalogues include cross-selling recommendations that can be displayed on individual catalogue pages. For example, a product page featuring a doll may contain links to accessories such as doll clothes or doll houses.

Customers are often addressed with advertising campaigns too, which control the banner advertisements customers view at the site. These advertisements, which can display a company promotion as well as that of a third party can be tailored to the customer shopping behaviour, customer profile, and order history. This tailoring is defined by establishing a set of rules for the personalization engine to follow. For example, a rule might specify that if a shopper has placed a best-selling novel book in the cart, the web page will display an advertisement for an upcoming book promotion.

Marketing of products varies widely from vendor to vendor. However, as basic sales and order management functions reach maturity, future competition will likely focus on the sophistication of marketing modules.

3.3.2.4 Order Processing

The order processing is the e-commerce component which manages the financial part of the sale process. Typically, this involves calculating the required taxes and processing a credit-card transaction, eventually providing the necessary security routines and merchant routing systems (processes, security certificates, and data formats for communicating with banks or credit-card processors) required to manage credit and debit payments directly.

3.3.2.5 Configurators

The typical online product catalogue is not flexible enough to display all the possible combinations of a product that has many parameters or variations, can be modified to meet a broad

range of customer requirements, or comprises many interconnected elements. To provide the necessary flexibility, a configuration application is often used.

Businesses use configurator applications, also called configurators, to speed the selling process, reduce errors in orders, and replace person-to-person selling with customer self-service. Selling products such as automobiles, high-performance bicycles, life insurance, mutual funds, desktop computers, and networking and telecommunications equipment through an e-commerce site typically requires the aid of configurators. The configurator clarifies the buyer's needs, optimises the product makeup, and prices the result. Configurators also may add such functionality as payment calculation or the ability to compare the advantages and disadvantages of leasing and buying.

The first configurators, introduced in the 1980s, were add-on modules to back-office order-entry or manufacturing resource planning systems. The configuration software verified the feasibility of the product configuration being ordered, thus avoiding situations in which the requested configuration was impossible to build or would not work if built, as would be the case if necessary parts were omitted. If a customer wanted to order a computer with five add-in cards but the computer was designed with only four expansion slots, the configurator flagged the inconsistency and gave the salesperson a logical alternative to offer the customer.

That type of configurator is known as a constraint-based system. Most modern configurators do more than ensure constraints are satisfied: they also include logic to optimise products. Optimisation algorithms make it possible to determine the best result on the basis of what is known about the needs of the customer.

With the rise of e-business and unassisted selling, a new class of configurators with easier-to-use web interfaces has been developed to enable consumers to select or configure a product correctly. These product configurators are the most widely used type of configuration application. Vendors have begun to offer specialised applications, called pricing configurators, that optimise pricing during each customer interaction. Like product configurators, pricing configurators can be accessed directly by shoppers on a web site or by salespeople assisting customers.

A typical configuration application has a model builder that evaluates and builds product combinations in accordance with the buyer's stated criteria and the system's rules.

Many enterprises use the configuration results stored in the application's knowledge base to collect and store customer information so they can personalise recommendations. Configurators support personalization, although the process requires another database and a personalization engine discrete from the configurator.

Customers interacting with a web site that uses a configurator application normally are shielded from the complex processes involved. They enter detailed information about what they are looking for in a series of web forms that the configurator uses to guide its search. For example, if a customer indicates that he or she wants to purchase term life insurance and is a private pilot (a high-risk factor), the configurator uses information when it models the ideal insurance policy. Once the model is built, the configurator searches its database to find

matches for the model: perhaps, in this case, three insurance policies that meet the customer's needs. The model is stored in the knowledge base where it can be retrieved for future customers with similar needs.

3.3.2.6 Personalization

Personalization is the selective delivery of content and services (such as specific product and service offerings, advertising, coupons, and other promotions) to customers and prospective customers. In short, personalization is the ability to track customers and respond to them in an individualised, personalised fashion on the basis of their current and past interests, contacts, and behaviour.

The use of personalization software represents an attempt by e-businesses to extend the concept of personalization to the Web and, more recently, to other channels. Online use of personalization is unique in that it applies personalization techniques (such as specific product and service recommendations) in an automated fashion in real time at the point of sale. It also is unique because it allows for instantaneous capture of customer data (clickstream, purchasing, demographics, and so on) in electronic format that can be used to generate and update customer profiles and to change the website content presented to the customer accordingly.

A good example of personalization in the brick-and-mortar world is the way a salesperson familiar with particular customers greets them by name and offers helpful advice and service every time they enter the store. In assisting customers, the salesperson draws on the current interests expressed by them as well as their preferences, which the salesperson has learned from past interactions. In a typical scenario, the customer might be shopping for a new sweater. Because the salesperson knows from past interactions that the customer prefers dark sweaters, she suggests one in midnight blue. The customer then selects a sweater she likes. However, the salesperson then may direct the customer to a similar sweater from a new line that offers better quality at a slightly higher price. The salesperson also suggests several pairs of pants to go with the sweater that she thinks the customer will like because she knows that the customer has purchased similar styles and colours of pants during previous visits.

The use of personalization software is an attempt to automate and extend to the online world the friendly advice and courteous service customers receive when shopping at their favourite brick-and-mortar stores. Automated personalization uses personalization engines that employ one or more intelligent techniques, such as collaborative filtering, rule-based systems, case-based reasoning, and neural network technology, and that work in conjunction with content management systems, and application databases to dynamically profile customers and match tailored content to their interests.

Personalization engines analyse a web site visitor's implicit information (mouse clicks, ages visited, banners clicked on, and so forth) and their explicit information (transactions, purchases, and demographics). This analysis provides the basis for profiling the data, grouping visitors into specific categories, and creating customer profiles. The personalization engine then uses this information to generate in real time specific commendations for products and services, ads, and navigational links for the visitor.

The dynamic profiling capabilities provided by personalization engines allow merchandisers and web site administrators to update their web store operations with predefined personalization rules and patterns that present promotions, advertisements, and customer service information to online visitors according to their specific profiles and behaviour. These rules and patterns allow the personalization engine to present visitors with specific content in response to certain actions, such as clicking on an ad or a web page for a particular product.

In short, the capabilities provided by personalization include these:

- Addressing customers by name and remembering their preferences.
- Showing customers specific content based on who they are and their current and past behaviours.
- Increasing website value through enhanced “stickiness” (that is, by viewing more content they are interested in, visitors will remain on the site longer and return for repeat visits).
- Turning first-time visitors to a web site into paying customers.
- Facilitating greater cross-sell and up-sell activities (thereby increasing the average order spend rate).
- Applying personalization across multiple customer channels, including the web, call centres, automated teller machines (ATMs), and physical stores or branches.

Personalization is used to support dynamic, real time customer interactions in the three main areas of customer interaction: sales, marketing, and customer service.

Personalization technology has been applied widely to support online sales applications by automating the ability to match and modify content (in the form of tailored product recommendations and targeted advertising and other promotions offering selected merchandise or services) to suit individual customer preferences. This matching and modifying can occur during a particular customer interaction, such as after the visitor has indicated his or her preferences by completing a form or abandoning a shopping cart.

Personalization is being applied extensively to direct marketing and other marketing operations. It also is used to analyse and model customer interactions to build more profitable customer relationships and achieve greater marketing success. The aim is to implement better customer interaction strategies that communicate the right message at the right time via the right channel.

Personalization technology finally is being applied to online customer service to assist users as they browse a site seeking answers to product related questions, particularly those concerning computer hardware and software and consumer electronics (cameras, printers, and so forth). However, personalization is not used in customer service to the extent that it is employed in sales and marketing. It also is being used to automate responses to customer inquiries, such as requests for product information or support help.

Coherently, the personalization engine generates recommendations, such as the following:

- Specific products and services.

- Cross-sells (suggestions for additional items or products that supplement items already selected for purchase).
- Recommendations for up-sells (offering the customer an upgraded or higher priced product than that selected for purchase).
- Advertisements and other promotions.
- Navigational links to other contents.

3.3.2.7 E- business Security & Privacy

B2B is steadily developing. On the contrary, B2C will take some time for its full-fledged development, since there remain institutional problems to be internationally solved, such as the development of trusty payment process for e-transactions, the institutionalisation of electronic verification and electronic signatures, and the protection of personal information. However, the institutional problems are being gradually solved.

As example, in Japan, the “Law concerning Electronic Signatures and Verification Activities” (hereinafter called the Electronic Signature Law), promulgated in May 2000, was at last enforced on April 1, 2001. Electronic signatures and verification are a scheme indispensable for enhancing the security of a network society, and the respective parties concerned count on the Electronic Signature Law as a core law for security. Since the Electronic Signature Law has authorised that a document with an electronic signature can be estimated to belong to the nominal person using the signature, electronic transactions can be made with security of transactions ensured, if the persons concerned confirm each other in reference to their electronic signatures. Furthermore, if electronic documents with electronic signatures are ciphered to prevent falsification, important private documents, such as contracts, can be exchanged also on the network.

Moreover, with regard to electronic administration, as to the problem of how to ensure the originality of a digitised public document, if the electronic public document has an electronic signature, it can have the same effect as a public document with the public seal of a mayor or the like affixed.

On the other hand, it should be noted that technological trends must be precisely followed also for institutionalisation of today’s society, where the importance of science and technology is mounting. A key factor for success of e-business is to establish relations with customers taking a long period of time, through mass customisation based on “One-to-One Marketing.” This importance has long been recognised, but it was too costly and unprofitable in an environment without networks. However, if an intelligent agent, personalised information database, and secure online system are used freely to elaborately combine networks with real stores, one-to-one data can be supplied based on identified individual persons’ attributes and needs, allowing customers to be kept contained. This contributes to the development of e-business, and hence development of the economy, but it also means the risk of violating the privacy of individuals is increasing. In a survey carried on during the last Japan technology foresight Delphi exercise, “The Seventh Technology Foresight - Future Technology in Japan toward the Year 2030”(Jul 2001), about 60% of respondents indicated “Negative influence on

safety and peace of mind” concerning security, electronic money, and DNA verification in the services field.

Free commercial transactions and security & privacy on a network are contradictory. For sound development of a network society in the future, it must be designed a better-matching scheme. It is important for everyone to think together and make a scheme with concern.

3.3.3 Evolution of Retailing

Retailing has faced a social and technological revolution since the coming of e-business and e-commerce. Actually, most major retailers see internet sales as one additional route to their customers, adding to, but not replacing, the traditional store, superstore and corner shop. We believe that in many cases a multi-platform approach is the key to long term sustainability in global markets.

The ways of regenerating the traditional store should include the design of facilities that reflect the impact of e-commerce on traditional shopping centres, such as providing the public with access points for purchases through the Internet, including collection and delivery points (CDPs), incorporating crime prevention measures, reflecting the changing composition of our Shopping Streets by including opportunities to “buy” new services e.g. via skills and learning drop-in centres and areas where health care advice can be accessed. As an example, we can examine the case of a local shop or Post Office with skilled staff able to assist customers to access and make purchases through the Internet. These would subsequently be delivered either directly to the consumer or to the shop or the Community Centre acting as a local collection and delivery point (CDP). Such facilities could also be a source of wider economic regeneration by providing information on, and access to, local suppliers of goods and services. In rural communities these could provide a form of electronic farmers’ market. On a regional basis such facilities could reduce the number of miles travelled by many fresh products with obvious benefits both to the local economy and environment.

More than this, traditional retailing will evolve to the offer of new services such as real time shopping cart products processing and real time secure checkouts and tax and shipping calculations in order to accelerate transactions and eliminate queues. New techniques and practices based on the e-commerce experience will be therefore combined with the traditional ones to provide the ideal shopping environment.

3.3.3.1 Logistics Transactions

Delivery is a process of commodities transportation. It refers to that commodities are made available to customers by commercial firms according to their demands. The concept of home shopping (or, more generally, remote shopping) is not new, with a long history in mature sectors such as catalogue shopping and door-to-door selling. Internet and e-commerce have created new methods of product selection and the corresponding increase in the range of products on offer has made home shopping attractive to many new users.

Ordering and paying for goods from home may never have been easier, but the increased range of goods on offer, high customer service expectations, changing customer behaviour and the sheer number of required different deliveries present major challenges to any company involved in home delivery.

Home shopping fulfilment and delivery systems need to be able to supply the right goods quickly enough and at the right time to suit the customer's needs and constraints and at the same time, efficiently and cost effectively enough to make home delivery profitable for the supplier.

The distribution pattern in e-commerce is customer-centric, zero lead time and technology-enabled. By the means of technology and modernisation, it can respond to customers in time, cut down the cost of management greatly and obtain the high profits as well as social benefits through the division and co-operation of specialisation.

The range of goods that can be delivered or distributed is extremely wide, such as groceries (all items purchased from supermarkets that are delivered to the customers home or another delivery point chosen by the customer), small packages (all small, packaged items delivered to the customers home), large items (large items such as furniture, white goods and other large electrical appliances).

Home delivery generally requires the following logistic transactions:

- Customers send their orders or demands to Customers Service Centre through Internet or telephone
- Customers Service Centre transfers these orders to Distribution Control Centre
- Distribution Control Centre sends shipment instructions to Storage Centre or Process Centre after calculation
- The instruction receiver asks the Transfer Centre or the third party distribution service organisation that may be involved, to perform the distribution service
- Transportation Centre or the third party distribution service organisation dispatches vehicles to perform the distribution service for customers
- Transaction is fulfilled when the confirmation of customers is received

These transactions require the development of the following tools:

- secure storage boxes
- collection and delivery points
- collection of data to improve understanding, operational efficiency and policy considerations about home delivery

Secure storage boxes

Secure storage boxes allow delivery companies to optimise transport routes and schedules and achieve better vehicle and driver productivity, as well as to reduce the total transport require-

ment for delivered each unit. This option has been tested in the United States, and property developers in Europe (including the UK) are installing these devices in some new houses.

Reception boxes are one system by which unattended deliveries can be implemented. Trials of reception/storage boxes are now taking place in the UK. In some systems the box remains permanently outside the house fixed to a wall. These boxes tend to be equipped with electronics and a communication system, so that they can be programmed remotely to provide access for specific deliveries each time they are needed. The customer has a mechanical key to access the box. In the case of other systems, the box is used as a container for the delivery and is attached to a cable outside the house by the driver. The customer then puts the empty box outside the house when he is expecting the next delivery, and the driver takes away the empty box.

All these systems obviously raise questions about:

- Potential theft from, and vandalism to, the box, as well as the security of the house itself, in the case of systems which provide garage or front door access.
- Planning issues, for example if the front door of the property fronts directly out on to the pavement, in terms of presenting a potential obstacle to pedestrians.
- Reception boxes will be more useful if they can be used for a wide range of products (including grocery) and if they can be shared by all companies making deliveries to the home rather than one nominated delivery company. However, it raises security problems if the box is easily accessible by too many people.

For grocery deliveries, such a storage device would need to be temperature controlled, unless the goods are delivered in an insulated box. Food safety and legal liability issues need to be addressed before such systems become a commonplace.

Collection and delivery points (CDPs)

Increased use of collection and delivery points (CDPs) could boost delivery efficiencies significantly, allowing delivery operators to optimise routes and schedules for deliveries. Goods could be stored at a CDP until it is convenient for the customer to collect them, or the operator of the CDP could deliver as part of a local delivery round. There is also scope for the CDP to act as a central facility for the management of any returned goods.

The goods are to be transported to the CDP by the carrier charged by the retailer. Then on arrival the barcode on the parcels are scanned by the site operator, then relayed to the service operator, who informs the customer that the goods are ready for collection. The customer then travels to the CDP and provides proof of identity before receiving the goods. Obviously each operation could be automated. CDPs may use banks of automated drop-off boxes which could be built into the outside wall of CDPs. With appropriate identification systems, customers could then collect their goods at any time that best suited them, either night or day.

Another possible scheme being discussed involves the construction of dedicated drive-through pick-up points for home deliveries. Customers would be, at the time of ordering, offered the option of having their goods delivered to a CDP. They would either get to choose a

convenient CDP, or indicate the area or postcode they would like the CDP to be located in. Customers will probably pay an additional fee for this service, as the customer using his own time and incurring transport costs to collect the goods makes home delivery systems far cheaper to operate. Alternatively the carrier, rather than the retailer, could decide to use the CDP system, or carriers may decide to take all failed deliveries to customers' houses to a CDP. These systems could also be used as a convenient method for customers to return goods.

These CDP systems will be suited to the handling of small packaged items only. They are unlikely to be suitable for handling grocery items because these would require a large refrigerated space. They will also be unsuitable for large, heavy items as these require a significant storage space, and convenience stores tend to have little unused storage capacity. In addition, many large item deliveries to the house involve the removal and disposal of old equipment (such as sofas and refrigerators).

Convenience stores have been relatively keen to participate in these systems. They perceive that offering this service may lead to additional sales, and may allow them to act as online ordering points in the future.

The alternative CDP concepts imply the need of evaluating whether there is an appropriate general solution or if different settlements (perhaps urban/rural) require tailor-made solutions. Considerations would need to include:

- the acceptability of CDPs to consumers and the type of CDPs that are most attractive to them
- the types of products that should be handled by CDPs (e.g., whether it would be feasible and sensible for large items and groceries to be handled by CDPs)
- how CDPs can be designed so that they don't prevent certain consumers from using them (e.g., those who do not have cars, or who live a long way from the nearest CDP)
- the other roles that CDPs could play in addition to their main purpose and the CDP function (e.g. they should also provide Internet access for viewing and ordering goods, and whether a dedicated CDP could also perform other functions for the community)
- whether decisions about the location and number of CDPs in each settlement should be left to the market or should be made in agreement with public administrators.

Data collection for the improvement of understanding, operational efficiency and policy considerations about home delivery

The development of e-commerce quickens the data exchange inside a firm, among firms and between the customers and the firm, so enabling the development of distribution business. High-speed data processing and communication make the real-time and complicated distribution control viable.

The type of data required to achieve a better understanding of home deliveries and to achieve a better customer satisfaction is likely to include:

- consumer preference data about issues such as the types of home delivery systems that are most favoured, the most preferred delivery times and days, and the amount that customers are prepared to pay for different levels of home delivery service,
- operating cost data for different home delivery options and systems
- growth forecasts for the home delivery of different categories of products
- trip generation data for home deliveries and impacts on passenger transport of home shopping and delivery
- environmental impact data concerning the effects of different home delivery options, and information about the comparative environmental impact of traditional shopping versus home shopping and delivery.

The collection of these data will allow the development of Key Performance Indicators (KPIs) for home delivery operations. KPIs could play an important role in both the monitoring of home delivery operations and also as a tool to improve these operations. They provide companies with data against which to benchmark their operations, and also standards to aim at. KPIs could also be developed for fulfilment operations as well as for home delivery vehicle operations. KPIs have already been developed for temperature-controlled food distribution covering factors like: vehicle fill, empty running, time utilisation, deviations from schedule and fuel consumption. Similar KPIs for home delivery are likely to include several of these indicators, together with some more specific to home delivery operations, such as:

- the time spent waiting on street during deliveries (which would obviously vary depending on the product being delivered)
- the proportion of deliveries that are successful the first time
- the proportion of deliveries that are made in full (i.e. whether all items ordered by the customer are present in the delivery or whether another delivery is required).

3.3.3.2 Mobile Commerce

Mobile commerce (m-commerce) can be defined as the extension of e-business to anytime and anywhere, typically using Internet-enabled mobile phones or other wireless Internet access devices. Otherwise m-commerce can be defined as the: “the ability to perform a commercial transaction in a wireless environment.”

International trends

M-commerce is seen as the next high growth area, due mainly to the fast growing diffusion of mobile phones. Nokia estimates that by 2005 there will be more internet-enabled handsets than PCs on the Internet. The market is forecasted to reach a large size surpassing e-commerce in 2003 and reaching a point of 700 million users in 2004 (source: Ericsson). In 2000 Ovum (2000) estimated that global m-commerce revenues would grow from € 4.5bn in 2000 to € 235bn by 2005.

Actually the on-going evolution and deployment of more advanced networks across Europe and the rest of the world are critical to exploit the full potential of m-commerce. The roll-out

of new networks and in particular, the roll-out of Third Generation (3G) networks, are critically dependent on the ability of hardware and software companies to develop the technology, and on the ability of telecommunication companies to fund this programme and to develop robust business models to generate revenues from the new services.

Currently, m-commerce has not taken off as quickly as expected in the US and Western Europe. Many reasons have been put forward to explain this fact, such as:

- Poor technical quality of WAP-enabled phones.
- Scarcity of compelling services.
- Poor quality, slow services.
- Unreliable connections.
- Complexity and difficulty of use.
- High cost, both of calls and of WAP-enabled handsets.

Most available WAP services are relatively simple and not attractive to the majority of potential users. Currently available applications include phone personalisation, social services (chat services, email, public SMS message boards, and so on), and content services (news, stock quotes, horoscopes and train timetables).

Some of the technical problems will be solved by GPRS (General Packet Radio Service). This is an emerging network technology that enables the transmission of high-speed packet-switched data. It provides “always-on access”, which removes many of the problems now affecting WAP and provides a far better user mode.

Much international attention has been focused on developments going on in Japan. In September 2001, NTT DoCoMo launched the world’s first 3G service using W-CDMA technology. The success of NTT DoCoMo’s Foma, the world’s first 3G service using wide band CDMA technology, is critical not only for DoCoMo, which is spending over € 9.3bn on infrastructure and more on the handsets, but for European operators who have spent an estimated € 98bn to acquire licences to offer 3G services.

M-commerce in Japan has been significantly more successful than in Europe. In Japan, the standard adopted is i-Mode, which is a WAP-like text-based mobile information service. Unlike WAP, however, i-Mode runs on a network that supports packet-switching technology. This provides a better user experience, and allows the operator to charge by the packet, or amount of data, rather than by the time the user spends on the network.

I-Mode allows users to send emails and to access specially configured web pages. About 500 of the most popular pages are stored on the handset itself, and more than 15,000 are readily accessible. There are more than 650 authorised content providers and 24,000 unauthorised content providers dealing with i-Mode users. Since its launch in 1999, NTT DoCoMo has signed up almost 30 million subscriptions to its i-Mode service. This success is due to the better quality of service, wider range of content and a more attractive pricing model. It may also be due to the lower PC/Internet penetration rate in Japan, and the popularity in Japan of applications such as downloadable cartoon characters. Entertainment functions such as car-

toons, games and horoscopes, account for 59% of access to i-Mode pages. Commercial transactions such as banking, stock price quoting, flights and hotel reservations account for 17%, while database functions account for 9%. The remaining 15% is accounted for by information services about sports, news and weather.

As Japan, also Europe is currently ahead of the US in the adoption of m-commerce for a number of reasons:

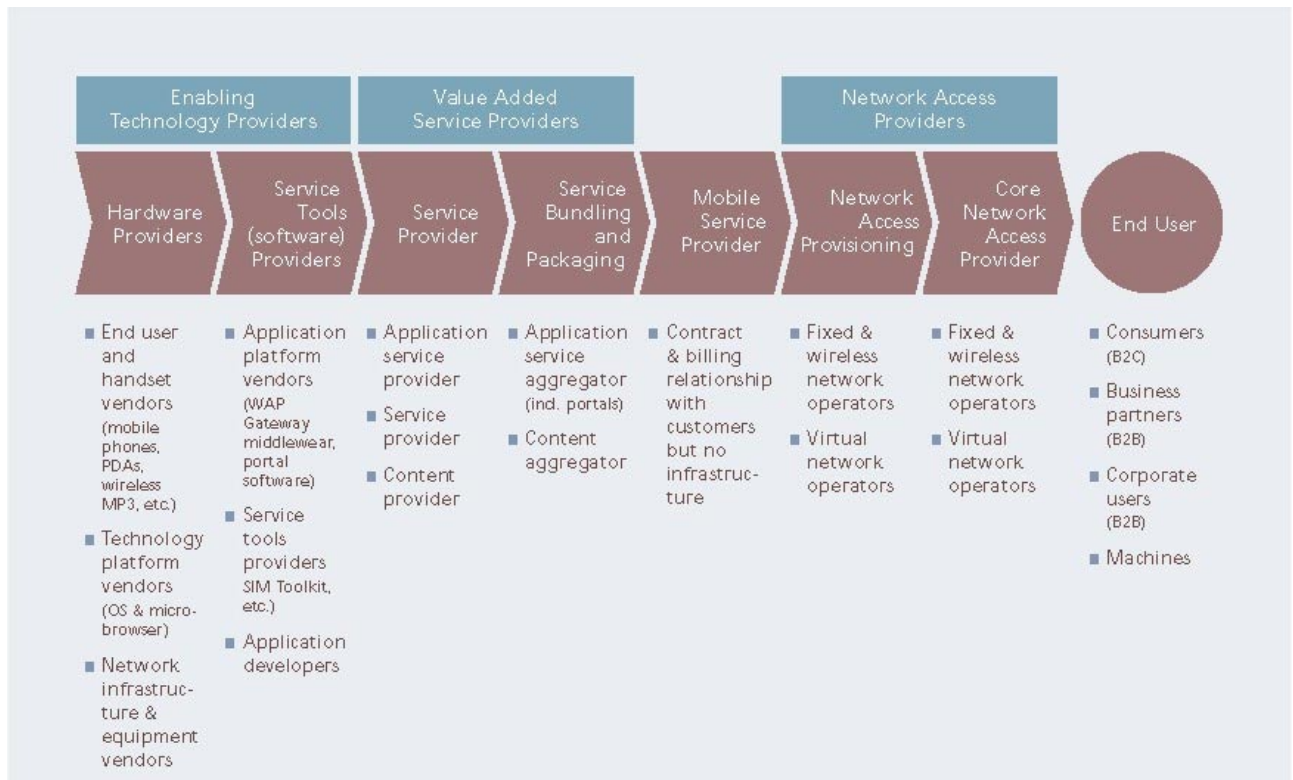
- Lower market penetration of wireless devices in the US.
- Lower handset turnover rates in the US.
- Mobile phone users in the US pay for incoming calls, unlike their European counterparts. This has slowed the adoption and use of mobile phones, and, as a consequence, the growth of m-commerce.
- The US has a higher penetration of PCs with Internet access. Thus, users already have access to a competing e-business channel.
- The US has a fragmented carrier market, whereas in other countries there is generally one dominant carrier.
- A number of different standards are in use in the US (TDMA, CDMA, GSM) whereas GSM has been accepted as the standard elsewhere.
- There have been difficulties with spectrum allocation in the US.

Value Chain

The m-commerce value chain includes:

- Hardware providers (end-user equipment and handset vendors, technology platform vendors, network infrastructure and equipment vendors, and application platform vendors) e.g., Nokia, Motorola, Ericsson, 3Com.
- Service tools providers, e.g., Jinny Software, Trintech.
- Service providers including content providers, e.g., banking, shopping and new media.
- Service bundling and packaging (application service aggregators and content aggregators), e.g., wireless portals such as e-merge.
- Network access provisioning (fixed, wireless and virtual), e.g., Vodaphone, O2, TIM, Meteor.
- Core network access providers (fixed, wireless and virtual).
- End-users (both B2C and B2B).

Figure 3 Stages in the m-commerce Value Chain



Source: Forfäs 2002

Advantages of m-commerce

Mobile commerce is likely to bring some advantages to all the key components of the value chain, such as the network operator (who will play a key role in the m-commerce world as it will have access to key data on the person and their location: the network operator in turn will benefit from increased customer loyalty and spending and will gain better return in investment on the infrastructure), vendor (the reseller is the part of the value chain which produces or sells the product or services the consumer demands; the benefits come from access to targeted user groups and more efficient sales processes), the consumer (who will be provided with a familiar device which will allow extra functionalities to help him to make day to day purchasing decisions at a time and place most convenient to him).

Generally, when looking at the market for m-commerce, there are three issues which stand out as critical: mobility, personalisation and security. Each of these is critical to allow for the user to achieve any added value over any existing transaction mechanisms.

Mobility

Mobility empowers the consumer: it's the "anytime anywhere" theory. Having the ability to place orders and buy on credit or to have access to e-cash enables the consumers to have more control over how they purchase goods. Using the mobile internet as part of the complete solu-

tion services will enable the consumers to find out where stock is available in the right size, colour or the best price.

It is the ability of the mobile industry to place all this in the hands of the consumer in a device they are already familiar with, the key driver for the success of m-commerce.

Security

Wireless networks already provide a more secure network the one offered in the fixed line markets. This can be further enhanced by using Digital Signatures (a kind of unique electronic stamp), authentication and encryption. It is the extra security that allows the users to have access to all their funds instantly, but without the risk of today's wallet.

Information

The information provided to the consumer and the reseller will allow mobile commerce to be a highly tailored solution. It is this above all, which is the key advantage of the m-commerce market. The information which is required to allow personalised solutions is identified into two areas: information about location and "personal" information. In particular, knowing the location of the client enables the resellers to immediately limit the options, which are then available to the consumers, when information about products or services are requested.

Merging personalization and m-commerce

Currently, on line stock trading, bill payments and access to company intranets and extra-nets use expanded security tools including end to end encryption, WAP and PKI technology. Blue chip companies that are already providing secure WAP environments are: VISA, Amazon, AMEX and Master Card. These applications are based on account profile allowing users to make informed decisions at their convenience. It is the personalised information, which makes these leading applications work. It allows filtered information to be delivered on narrow bandwidth connections; this is very important for the ergonomics of the sites. It also increases the security of the transaction if the financial details are not transmitted. The example of the Amazon m-commerce site is provided to Club Nokia customers. It works for customers who have an existing account with Amazon and therefore, authentication procedure and a degree of security already exist. The back-end database of customer details and log files are already in place, offering much shorter time-to-market.

About future development, there is always a bit of "Blue Sky" thinking in how these applications will work, however. As the m-commerce has the unique selling proposition of being with the customers most of their day and night time, it does enable a totally integrated "life-style" application in the future. To the end user this life style application may be like the following tries to depict: "The day starts with a business meeting which is hosted in a diary within the network, both you and your defined user group have access to this information. In two days time it is Valentines Day and you have set an alert to remind you of this event. The alert comes through when you have just finished the meeting. As you are at the client's address you are not aware of the surroundings and want to find out where the nearest record shop is to buy an Elvis CD. Using the services, which are supplied free of charge by Yellow

Pages, the nearest record shops are presented. A simple search function identifies the shops with the particular record in stock and the shop that is providing it at the best price. Using a finder link next to the shop a defined route to the store is presented. On your way you step in a puddle and realise that you have a hole in your shoe. This is no ordinary shoe as you have size n° 13 feet. On the off chance of any shoe shops in the locality that stocks this size you search the database, the network already has the information about your person and will not need to ask the shoe size. The search comes up blank, but it presents you with your catalogue link that you have used previously for this service. You place the order. No exchange of your personal or financial details has to be sent as the account is already set up; however you will have to confirm the order. As you are going to your next meeting, the network understands the geographical difference between where you are now and where you want to be; suggested modes of transport are sent to the phone and options to purchase and reserve a seat are provided.

Finally the day is at an end and on your way home you place an order for a pizza at the same time receiving a discount through payment via mobile. This turns up to your home as you arrive due to the ability to place a time of delivery.”

As mentioned before these services are visionary today; however the ability to create this life-style application is fundamentally dependent on the data being made available.

Emerging trends

Finally, although m-commerce is still in its infancy, a number of key trends are emerging and can be outlined:

The volatility in the stock market and the high cost of 3G licences have weakened the financial position of many European telecommunication companies. This will delay the upgrading of Europe’s networks.

NTT DoCoMo will be in a very strong position to challenge the incumbents in the European market, due to its experience with i-Mode and the fact that it will be one of the first companies to launch a 3G service.

As with the Internet, the availability of good contents will be critical to the uptake of m-commerce.

Market size and growth rates, initially forecasted, actually could only be achieved through advancements of technology (location based services) and smarter and more efficient collation of data through web based models.

The implication of personalisation in m-commerce may be positive and essential.

3.3.3.3 Voice Technologies

Voice technologies are enabling technologies used to process human or machine-generated speech.

Voice technologies include:

Speech Recognition, which is the process of using complex statistical modelling to recognise what an individual person is saying.

Dictation, computer transformation of speech into text for recording or control of software.

Language Translation – this includes Machine Translation, which is the transformation of text from one language to another one.

Speaker Recognition automatically recognises who is speaking by assessing the individual information included in speech signals. It consists of speaker identification and speaker verification or authentication. Speaker identification is the process of determining who is speaking, while voice authentication is the process of accepting or rejecting the identity claim of a speaker.

Speech Analysis is the dissection of speech into its core components in order to obtain information.

Speech Compression is the process of creating compact speech signals so that when it is reconstructed, it is perceived to be close to the original.

Speech Synthesis is the production of an artificial voice by a computer.

Relevance of voice technologies for mobile applications

Three voice-related technologies will likely emerge as key ingredients in the delivery of wireless applications: voice recognition, text-to-speech conversion, and voice authentication. Although voice technology has been around for 5 to 10 years, it is now coming to the fore as a mainstream technology. Among the factors which are making it important now there are:

- The technology has become better. Speech recognition software engines are self-learning, which means that the more they are used the smarter they get because the statistical algorithms in their solutions have more examples to choose from. The leading technologies are now reaching accuracy of greater than 90% in multiple tonalities, language, accents and speaking rates. These solutions are now effective for mainstream use in a host of settings – indoor, outdoor, wired and wireless.
- Mobile Internet is of growing importance and voice technology can overcome the limitations of existing mobile devices.
- Voice technology can bring the Internet to the users of land-line phones.
- Voice enablement is the next generation of call centre applications. Interactive Voice Response (IVR) is the first wave of this, but IVR provides one way of communication only. The new wave of voice-enabled call centres will lead the way for the replacement of call centre agents.

A report by the Kelsey Group (2001) predicts that spending and revenues from voice applications will reach € 45.6bn by 2005 from less than € 5.6bn in 2001.

Value Chain

Voice technologies are an emerging field and as such it is difficult to classify the various elements.

Based on the state of the market now, there are eight main types of players in the value chain for the use of voice technologies:

- Application Developers – application developers create voice applications usually in Voice XML 5.0 and typically offer consulting services to voice-enabled organisations. Examples of application developers include Bluewireless and Lernout and Hauspie.
- Application Service Providers – application service providers host voice applications and may offer other services. Examples of ASPs include TellMe Networks and Vocal.
- Network/Platform Providers – major telecommunication companies have long offered voice services, but they are now tailoring their offerings to take emerging technologies into account.
- Security Providers – security providers offer both products and services in speaker identification.
- Speech Recognition Engine Providers – speech recognition is the dominant concept in voice technologies. Providers of speech recognition engines include IBM, Philips, which has the largest natural language portfolio (22 languages) and Nuance, providers of speech recognition and speech authentication software.
- Text to Speech Engine Providers – they are companies such as Fonix which supports voice solutions for wireless and mobile devices as well as Internet and telephony systems.
- Traditional IVR/Telephony – most established IVR companies have begun to provide voice services.
- Voice Browser Developers – voice browser developers create the software that interprets Web site and application Voice XML.

Recent trends

Among the trends one finds both barriers and drivers.

Among the barriers to the rapid development of voice recognition software and services there are:

- Lack of Standards – Voice XML 1.0 is a very new standard and, as such, many vendors have based current offerings on custom proprietary extensions.
- High Cost – developing voice applications is an expensive process, from the design stage alone.
- Unsophisticated Devices – smart devices are still not intelligent enough to handle voice and data simultaneously. For the mobile user, speech recognition can exist only when connected. Devices of the future need to have greater storage and faster processors and need to provide for disconnected use.
- Business Re-Alignment – businesses potentially face a strategic human resource issue by opting to replace call centre representatives with speech recognition systems.
- Cultural Attitudes – cultural attitudes represent the largest obstacle. For example, there are people comfortable with voice verification as an identification mechanism; should speech

recognition be used in public places, will elderly people be comfortable when talking to a computer?

Among the drivers of voice technologies there are:

- Revenue Generation – voice technology extends its reach to numerous devices and individuals.
- Voice enabling adds new services to distribution channels, by creating v-commerce (voice-enabled commerce) opportunities. Also, additional value-added services increase the “connect minutes” of mobile customers for telecommunication companies.
- Cost Reduction – replacing or alleviating human operators with speech systems can significantly reduce business expenditures. Additionally, call centre agent turnover due to tedious routine calls can be reduced.
- Accessibility – voice technology is available on multiple devices which are becoming more prevalent.
- Security – voice verification provides an additional confidence factor for access to sensitive information.
- Efficiency – individuals prefer voice to DTMF interfaces when it comes to navigating long menu chains or specifying a choice from numerous options.
- Convenience – the use of natural language means that computer-illiterate individuals can access information without having to learn new procedures and methods.

3.3.3.4 Digital Asset Management and Digital Rights Management

Digital Asset Management (DAM) encompasses strategies, technologies and processes required to create, store, retrieve, approve, distribute and leverage rich media content such as video, audio, images and graphics, as well as text. Digital Rights Management (DRM) systems are designed to protect the intellectual property rights of the creators and distributors of digital contents.

The increasing use of the Internet for distribution of all sorts of contents, from the text and photographs in a news story to digital music and video, has presented content owners with the problem of how to exploit new markets and delivery channels while preventing unauthorised copying of content. Digital content distributed on physical media, such as DVDs and CD-RQMs, also is subject to unauthorised use; therefore, DRM concerns extend to those more traditional channels as well.

The problem is acute because the same factors that make digital distribution attractive also make it dangerous. Digitised content, in contrast of the analogue one, can be sent over the Internet or copied from one disk to another without any degradation in quality. The consumer receives a perfect copy of the original, and any digital copy the consumer makes is perfect as well. The ability to make an unlimited number of perfect copies is an opportunity for piracy on a massive scale. Nothing illustrates the problem for content creators and distributors more than the well-publicised Napster controversy, in which the Recording Industry Association of America made a sue in order to shut down a service that enabled subscribers to exchange

digital versions of songs without payment to the copyright holders. More than just downloaded music is at stake: e-books, online catalogues, Web-based publications, and dozens of other content sources on the Internet face the problem of maximising and preserving the value of their intellectual property

The same concerns apply to digital content delivered on physical media. As with downloaded music, a digital copy of a movie from a DVD is as good as the original, and even an analogue (videotape) copy looks as good as a pre recorded tape. Without some forms of copy protection, movies on DVD would be as vulnerable to piracy as recorded music. Until recently, technical problems have restrained DVD piracy: digital video files are much larger than audio files, and few options existed for recording the digitised video back to a physical medium. As network bandwidth increases and DVD-R drives become more common, those limitations are vanishing, making DVD copy protection even more important.

DRM covers the spectrum of usage concerns, from preventing piracy to enabling payment. It provides a way for content creators to be recognised for their original work and for content distributors to maintain control of their assets. DRM systems enable owners to specify and enforce the rights consumers acquire when they purchase a content: whether they can make copies, only one copy can be made, access the content forever or only for a limited time period, transfer it to another device or person, and so on.

Much early DRM development approached the problem of distribution from the restriction side by attempting to thwart or detect piracy rather than increasing access. However, publishers and distributors have realised it is more in their interest to encourage wide distribution in a way that preserves their rights than to concentrate on limiting consumers' access. It is likely that if the recording industry had come up with a consumer-friendly way to distribute digital music on its own terms, Napster and other music-sharing services would not have become such a problem in the first place.

The obvious analogy is to the VCR, which in its early days was regarded as a threat by movie studios. In a landmark legal case that reached the U.S. Supreme Court in 1983, Universal Studios and Walt Disney Productions argued that Sony, as a manufacturer of VCRs, was guilty of contributing to copyright infringement because Sony's machines permitted the recording of copyrighted works. The Supreme Court decided that VCRs had a substantial non infringing use (specifically, the recording of a copyrighted work for private viewing at a later time), and that such use would not harm the market for the copyrighted movies in any case. Today, of course, the video market is a significant revenue source for movie studios. Digital distribution offers the same potential for publishers, recording companies, and other copyright owners. By enabling commerce in digital content, DRM is not a barrier to, but a catalyst for a vast new market.

Value Chain

There are four main parts of the value chain for DAM and DRM services:

- Content Creation, Packaging and Digital Asset Management (DAM) are concerned with the process and technical capabilities to support the development of digital content. It covers the creation of content, the development of reusable media-neutral content, the creation

of digital libraries to store and manage this content, the customisation of content based on users' preferences and profiles, and the publication and secure distribution of the content in finished format. It also covers the creation of meta data (data about data) in order to provide detailed information to allow for searches and customisation.

- The Application Delivery Platform is concerned with the technologies required to support, enable and deliver these services. The area covers the backbone technologies that are used by the enterprise and by the Internet to transport digital content at a high speed. It also covers areas such as physical hosting, and access technologies such as xDSL, cable modems and so on.
- Content Consumption and Access covers the capabilities needed to support consumer access and interaction with digital content services. It covers such areas as the physical device used to access the content, the operating system and the application software on the device, as well as collaboration technologies that allow real-time access via shared documents or shared messaging.
- Enterprise Infrastructure covers the capabilities needed to support a content business, such as order management and transaction support, customer care and the distribution of financial information to all involved parties.

Recent trends

Among the trends in this industry there are:

- Increase in digital content – there is a general trend to move physical assets into digital form.
- Greater emphasis on digital asset reuse – digital assets are being reused to save development costs and to generate additional revenues for each asset.
- A single DAM system for all digital assets – many companies would like to store all of their digital assets in one system regardless of media type.
- Integration with downstream systems – DAM vendors are developing alliances with Web content management vendors. Integration with DRM systems will also be critical.
- Focus on brand management – companies from many industries are focusing on e-marketing and trying to develop, manage and use their brand assets in both the electronic and the physical worlds.

The stock market volatility is affecting the digital content sector. Rupert Murdoch's US-based subsidiary News Digital Media, is drastically scaling back its Internet operations. This follows a similar cost-cutting exercise in the UK, where the majority of staff in News Network (UK digital media company) were laid off. In October 2000, the *New York Times* withdrew its planned IPO for its online component, New York Times Digital, due to weak market conditions.

However, many of the large media companies are making substantial investments in digital content services projects. For example, Universal Studios has implemented a DAM initiative for stills, publicity photos, artwork and trailers. Universal Music Group has teamed up with Akamai to offer Internet Programming services for broadband delivery of music using Win-

dows Media, Real Networks and Apple's QuickTime Formats. CNN plans to convert its vast video library to digital form over the next five to seven years. The newly designed system will digitise, catalogue, store and distribute more than 120,000 hours of archived material.

3.4 Education and Learning⁶

3.4.1 Introduction

The new Knowledge Society offers important opportunities and challenges for Ambient Intelligent applications especially in the education and learning domain, which plays a primary role.

The rapid evolution of information & communication technology and science requires continuous professional updating since nowadays teaching - so far confined merely to school years and venues - is being considered as a lifelong learning, and as an unending training process. On the other hand, technological innovation has contributed to the development of better teaching support tools, thus allowing for a flexible and customised learning plan which provides people with equal chances to access to and success in the school, work activities and in general lifelong.

The ICT revolution puts the emphasis on the *learning centred* pattern rather than on the *teaching centred* model.

The new education/learning paradigm is based on active learning approach (to learn by doing, communication and sharing) rather than passive learning approach (to learn by watching and listening, Montessori etc.)

The active methodology proposes:

- to learn with all the sense (by eyes, ears, hand, nose and taste);
- to learn with all methods (at school, on network);
- to access knowledge without space and time constraints (anywhere and anytime).

While the didactics' heart of the teaching centred model is based on teachers and their knowledge, in the learning centred model learners play an active role by building, according to a *customised learning action plan*, the knowledge and training path best fitting their own pace and style.

⁶ This section is based mainly on the following sources: European Commission, DG INFSO 2001, 2002a; Bélisle et al. 2001; OECD 1998; Marchionini and Maurer 1995; Hooper-Greenhill 1991, 1999; European Commission, DG Education and Culture, DG Employment and Social Affairs 2001.

All of the above is part of a new scenario where education & learning is not confined mainly to school years. On the contrary, the need for knowledge and training lasts a whole lifetime (i.e. lifelong learning) both at the professional and at the personal level.

Educational/learning process become more and more flexible, independent and permanent and actually all education/learning phases are integrated and projected into a ubiquitous learning environment, based on a horizontal approach in terms of methodologies, technologies, tools and services.

The future technologies for Education/Learning in the AmI@Life scenario will be especially oriented to organise the knowledge. The more important phases in the Knowledge organisation are:

- acquisition,
- validation,
- representation,
- dissemination.

In the AmI@Life the knowledge organisation have to be new methodology droved, advanced ICT supported and new common standards based.

In the future Knowledge Society the knowledge will be direct accessed by the Cyberspace. In the education/learning area the knowledge will be organised in Learning Objects (LO) that represent *a reusable media-independent chunk of information used as a modular building block for e-learning content (see glossary)*, where for information we consider not only a document, but an expert, an experience, a contact, etc. In a future view we can envisage a *Knowledge space* full of LOs like web-seminars, lessons, digital libraries, digital museums etc. All LOs will be organised by standard meta data classification system and available in network.

In this *Knowledge space* a user giving only their desiderata (user profile) will build a personal learning path resulting by LOs connection and integration and suitable with their needs (profile).

The common standards (as SCORM) will be necessary to manage knowledge and their learning objects (trough meta data) in efficient and effective way in this advanced ICT scenario.

The main tools and applications in the Education /Learning future scenario will be oriented by following driving factors:

- virtual environment and virtual community
- use of the Intelligent Agents in the learning and evaluation knowledge process
- seamless, adaptive and interactive User Interfaces
- intelligent retrieval tools
- active network at local, civic and global level

- mobile technology
- growth in computer capacity/speed, shrinkage in computer size
- display devices evolution
- low-cost communication and computer technology
- ubiquitous use intelligent robot.

On 21 November 2001, the Commission adopted a Communication on “Making a European Area of Lifelong Learning a Reality” (European Commission, DG Education and Culture, DG Employment and Social Affairs 2001.) where the education & learning area is divided in three forms:

Formal learning is the learning typically provided by an education or training institution, structured (in terms of learning objectives, learning time or learning support) and leading to certification. Formal learning is intentional from the learner’s perspective.

Non-formal learning is the learning that is not provided by an education or training institution and typically does not lead to certification. It is, however, structured (in terms of learning objectives, learning time or learning support). Non-formal learning is intentional from the learner’s perspective.

Informal learning is learning resulting from daily life activities related to work, family or leisure. It is not structured (in terms of learning objectives, learning time or learning support) and typically does not lead to certification. Informal learning may be intentional but in most cases it is non-intentional (or “incidental”/random)

In the future scenario Lifelong Learning should more and more takes place throughout life in these forms, none of which ought to be exclusive. Therefore the learning should be based upon four pillars: learning to know and learning how to learn; learning to do; learning to live together; learning to be.

Following the EU framework and the future technologies availability, the education & learning area will divided in two sub areas: formal and not formal learning.

The informal learning will be analysed in Culture/Leisure/Entertainment area.

The table 3 shows the main contest of use and some specific social categories relevant to the Education & Learning area.

Table 3 Structure of the Education and Learning Application Area

Education/ Learning area	Type of Contest	Context of Use	Users
FORMAL	Public Sphere	School/Higher Education, Research Organisations, Library, Museums, Archives	Educators, Teach- ers, Pupils, Learn- ers, Mentors, Tu- tors, Trainers, Trainees, disabled people, re- mote/worker learn- ers, virtual com- munity, mobile workers
	Private Sphere	Companies for Educa- tion/Learning/Training, Home	
	Work Sphere	Companies, Organisations, Public/ Private Institutions, etc	
NON FORMAL	Public Sphere	Local community, voluntary organi- sation, ethnic minority centres, NGOs and adult education centres	Citizens, Learning facilitator, mobile workers, adult peo- ple, youth, elderly, disabled people, mobile workers
	Private Sphere	Learning groups, Family, Home	
	Work Sphere	SMEs mobile work	

3.4.2 Formal Learning

In the educational and learning future scenario, the formal learning should be use all the available advanced technologies and tools together with traditional learning framework in a blended learning scenario where learning events should combine both online and school/work place aspects.

Moreover the advanced ICT and tools could reach learners otherwise unreachable or in socially, physically disadvantaged learners: *860 million adults are illiterate, over 100 million children have no access to school* (UNESCO United Nations Literacy Decade 2003 – 2012)

Examples:

- Pupils in hospital connected with own classroom;
- Pupils in rural community;
- Learners historically under-served (girls and women that face cultural and physical obstacles to come to educational institutions, who lives in third world countries, adult workers, prisoners, etc.);
- Interaction with parallel classroom from different countries to reach a world citizenship using a multi-lingualism;
- Vocational guidance using role games and virtual reality and training (simulators);

- Remote and mobile workers (executives, sales people, professionals, emergency services workers, technicians, etc.);
- Exchange of experience, competence, learning needs, learning method between Universities, Research Institutions, SMEs (Small Medium Enterprise).

As concerning the formal learning area we have analysed the structured and valuable Education and Learning both at School/Higher Education and Work/training sub fields.

3.4.2.1 School/Higher Education

The use of new ICTs in the school has generated a new approach both to organisation of contents, and to process of delivering these contents to students.

On the one hand Internet, educational multimedia, innovative learning materials, successfully are already used in the traditional learning methods during the face to face (F2F) lessons that involves a traditional classroom communities.

On the other hand the innovative technologies (virtual reality, intelligent navigation and tutoring tools, Internet and high-speed networks, Interactivity tools and integration of networks) support the new generation of distance learning approach targeted to individual learner or to virtual class communities.

This sub-field is articulated in the following key functions.

Face to Face (F2F)

This key function is referred to the teaching-centred model in the traditional/virtual classroom environment.

Distance Learning/E-Learning

Distance learning can be defined, in the most general terms, as a method of education that involves an instructor and student(s), who are separated geographically and must rely on one or more methods of long-distance communication. It is the direct descendent of correspondence and home study courses, that were developed in the 19th century.

The use of ICT in the distance learning, named e-learning, have the function to facilitate the flexible construction of personalised learning, adaptive learning environment which enable the individual learner to acquire knowledge just in time, anytime and anywhere tailored to his personal learning need. At social level the Distance Learning enables also the weaker to access Education and Learning.

Evaluation/accreditation

This function is related to validation, certification, accreditation of knowledge and competencies acquired during a learning process.

The self-evaluation in the learning-centred model supported by advanced technologies actively contributes to design and redesign the individual learning path.

In the e-learning process the assessment and examination procedure will include on line candidate authentication. New method of assessment based on simulation, gaming and teamwork will be used in the evaluation/accreditation contest.

3.4.2.2 Digital Libraries

Digital libraries allow teachers and students to use information resources and tools that have traditionally been physically and conceptually inaccessible. Digital libraries open new learning opportunities for global rather than just local communities; they combine technology and information resources to allow remote access, breaking down the physical barriers between resources.

Digital libraries lead to integrated resources (printing, photography, computing..) and types of learning (formal, informal, professional...) and provide teachers and learners with knowledge bases in a variety of media (multimedia, simulations...).

3.4.2.3 Digital Museums

Multimedia information access on the Internet creates a new paradigm for museum information and education service that complements conventional school programs. Digital museum permits easy access to the cultural heritage stored in the museums around the world. A combination of real artefacts exhibition and multimedia information access in the museum has been regarded as a new education method.

Digital Museums allow learning by direct access to exhibition artefacts; enhance museum education by interactive multimedia technology.

3.4.2.4 Work/Training

Market globalisation is producing huge changes in job market both at production process level and at organisational level. It has required dynamism and flexibility in company management, organisation and facilities to fit the market needs. As the employment market is no longer stable, jobs for life evolve in fixed-term work contracts. That is why the worker has to continuously update his professional knowledge to remain employable and to enrich own competencies (training and re-training process).

A main issue of the new global economy is the unprecedented level of flexibility required for companies to stand the pace and effectively compete in a world-wide, ever changing market. Development and update of the capability to react quickly to intervening factors as e.g. technology advances, trade liberalisation/deregulation, oscillations in supply or demand of a commodity/service etc. peremptorily request a continuous learning process almost indistinguishable from the job itself. The knowledge management is then an essential factor that strongly affects the learning process and the specialisation both at workers level: the *just in time*, the *just-as-required*, the *on-the job* training/re-training; and at organisation level: the *learning organisation*.

Key functions for training sub-field are:

- (1) Face to Face
- (2) E-Training
- (3) evaluation/certification (in this sub field both considerations and technologies described in evaluation/accreditation sub-field are valid)

3.4.3 Non-Formal Learning

Need of continuous adaptation and active participation in a society changing towards a highly technological information society involves the continuous non-formal learning process of people not sufficiently computer-literate to enable them to get benefit from the possibilities given by technology penetration in a social contest (culture, leisure, entertainment, electronic commerce, smart houses, etc.) to satisfy the desire of knowledge which the future knowledge society will offer and to take all the opportunities in order to improve their own social integration into the Aml@Life.

In the future scenario, where the digital device (the gap between those who can access and use ICT effectively and those who can not) will not exist due the ICT literacy, the non-formal learners can take advantage of knowledge space learning opportunity.

The non-formal learning will promote the personal fulfilment, active citizenship, social inclusion and employability/adaptability.

Examples:

- The intelligent tools will extract documents and knowledge customised user topics, user profile and user goals;
- Exchange of experience, competence, learning needs, learning method between local communities, voluntary organisations, ethnic minority centres and adult education centres;
- Active participation to e-government and e-commerce, and active citizenship;
- The easy and customised access to not formal learning will facilitate the reconciliation of work, family life, and the other caring responsibility.

The non-formal learning form can be accessed both in learning centres and at individual learning level.

3.4.3.1 Learning Centres/Individual Learning

The value of learning opportunities, provided in the non-formal forms, especially involve adult education, voluntary sector, NGOs and local, regional community organisations.

In the future scenario using advanced ICTs will promote a culture of learning in non formal area, where there will be the need to develop learning communities, cities and regions and to establish local multifunctional learning centres.

The learning centres will increase, in the youth field, the participation in the society, acquiring values of tolerance and democracies, in the elderly field the inclusion in the society and culture in the digital age.

Moreover, in the future scenario, the ICT diffusion and low cost will give the opportunity to access the knowledge space in the individual way: in any location, on the move.

3.5 Culture, Leisure and Entertainment

3.5.1 Introduction

Ambient Intelligence has the potential to drive important changes in the three fields. These three fields are still quite broad and are therefore divided into sub-fields. There are of course differences between them and within each field but many of the functions AmI can provide might in the future, as AmI becomes increasingly available, converge into 'total' experiences whereby the traditional boundaries between for instance culture and entertainment, or information and communication are blurring.

Enhanced and enriched leisure and entertainment services for the consumer mass market is so far the first driver for many of the AmI technologies and could well be one of the more promising commercial markets for AmI, given its potential volume. But at the same time, this mass market might be one of the most difficult to address, given in particular the price-sensitivity of consumers. Usually consumer demand rises as prices of entertainment hardware and software decline but predicting how consumers will react to new ICTs and to new AmI environments is difficult. Carefully managing users' expectations about the capabilities of a new product is critical to win their acceptance. To arouse interest in new products, companies often release idealistic conceptualisations of the new functions. Unfortunately, these concepts may raise the expectations about the performances too high and many users may become frustrated and disappointed if the product does not perform accordingly (Ferguson 2001).

The driving forces can still be different however as the leisure and entertainment sector, together with communication facilities, are more shaped by commercial interest and private industries compared to cultural heritage, participation and socialisation. However, for the realisation of AmI within these fields, there is not doubt that it will depend on public-private partnerships between many different actors.

It is worth noting also that entertainment services rather address passive audiences than active users. But this might exactly constitute one of the challenges for AmI as it should be in a laid-back mode (IST Advisory Group 2002).

Audio-visual entertainment, especially television, has become the most popular leisure activity in most countries on the basis of time spent to watching TV, but it should not be assumed that out-of-house recreation will disappear as virtual facilities will improve. Data on consumer expenditures and time spending patterns shows that since the 1960s, the percentage of leisure time spent inside the home and outside the home has remained relatively stable (65% versus 35%). The activities for which people go out have changed however. Restaurants, trips, amusement parks, events and manifestations have become more popular at the expense of visits to cinemas or theatres for example.

AmI could, for instance:

- Enhance and personalise the experience of visiting historical sites/museums/exhibitions;
- Increase access to, retrieval of and control over multimedia and cross-media content (cf. Personal Video Recorder, digital TV, pro-active agenda & pro-active programming);
- Make self-customisation of content possible and context-aware entertainment (e.g. selecting music or programming that fits your mood by relating a songs emotional feel to quantifiable musical features such as tempo and beat intensity (Sleeth 2002));
- Provide more immersion towards 'total' experiences (Cf. Virtual Reality), e.g. via 3-D real-time holographic and via cross-media content (e.g. TV programs using Internet, printed media, radio, SMS);
- Offer context-aware and location-based services (cf. Mobile game experiences promoted by Nokia and thus creating game communities);
- Provide more peer-to-peer exchanges via intelligent agents, also mobile file swapping.

3.5.2 Cultural Heritage

3.5.2.1 Preservation and Digitalisation of Cultural Heritage

Preservation and digitalisation of the exponentially increasing cultural heritage is a major issue, considering that the total stock of written material doubles every seven years.

The challenge is not so much to digitise what is produced from now on but to deal with the huge and dispersed stocks. However, digitalisation as such is not sufficient. It is important for the readers to be compatible with old materials (e.g. magnetic bands) and to regularly transfer

all the stocks to the new well-established standards. For instance, it is not anymore possible to read the magnetic bands from the Martian probe Viking dating back 1976 because no compatible reader is available yet.

It is also necessary to record as much information as possible from the “physical” works of art (paintings, sculptures, architectures, monuments, perfumes, gastronomy...) so as to keep a trace in case of loss due to natural causes (natural decomposition, fire, floods...) or human-made disasters (thefts, wars...).

The new ICT are central to this function; however it is not certain that Ambient Intelligence as such will make a breakthrough here. Highly automated digitalisation processes and workflows are to be developed as well as the restoration and digitalisation of film and video materials. It will be important to have open standards widely diffused.

3.5.2.2 Organisation of Cultural Heritage

Information which is not classified and easily accessible cannot be considered as knowledge. The issue here concerns the classification and indexation of the huge and exponentially-increasing quantities of books, papers, reviews, musical pieces, recording of any kinds, radio and TV programs, films, photos, the “physical” works of art and the multimedia works to come (meta-data). All these pieces have to be put into relations and accessible in terms of their authors, origins, timings, histories, subjects, appearances, materials and moreover in terms of their contents.

Knowledge technologies such as advanced data warehousing (object and multimedia databases), Knowledge Discovery in Databases (advanced searching & data mining) are expected to be major contributors. Also numerous systems across the world have to be connected and made compatible.

3.5.2.3 Access to and Retrieval of Cultural Heritage, Digital Libraries

The issue is to make the common, world-wide cultural heritage widely accessible to everybody, whereas preservation and organisation of cultural heritage may concern primarily specialists or “cultural workers”.

The multimedia material should be easily accessible via multimedia rentals and digital libraries online or in the real world (e.g. Video-on-Demand). This function has important implications for the continuing education and training. Digital libraries allow teachers and students to use information resources and tools that have traditionally been physically and conceptually inaccessible. They have opened new learning opportunities for global rather than just local communities; they combine technology and information resources to allow remote access, breaking down the physical barriers between resources.

These services should be provided in a user-friendly way, at low costs, in order to benefit all people and to concretise the vision of life long learning and training. Viable business models, including relevant public subventions, have to be developed for the content of high quality which may interest only a small minority of people.

The emphasis being put on user-friendliness by the AmI vision and technologies is capital. The knowledge and Artificial Intelligence technologies: advanced data warehousing (object and multimedia databases), Knowledge Discovery in Databases (advanced searching & data mining), cognitive vision (pattern recognition, fuzzy matching, content-based image indexing & retrieving) are expected to be very important. Any kind of natural-language query should be allowed to access to this common, world-wide cultural heritage.

The requirements on communication and networking are also important, high-bandwidth access is to be available to distributed large-scale repositories of culture, history and science.

3.5.2.4 Intelligent Heritage and Cultural Tourism (Historical sites/Museums/Exhibitions)

The issue is to enhance and personalise the visits of historical sites/museums/exhibitions. Multimedia information access on the Internet already creates a new paradigm for museums and exhibitions. The cultural tourism of the future will be a combination of exhibitions of real artefacts and access to virtual multimedia material from cultural heritage stored in museums and exhibitions around the world.

This function has important implications for the continuing education and training; visiting museums and exhibitions is already an important complements to the advanced and interactive education methods.

Some visions we may have from this field of application include:

- Recreation and animation of historical or cultural objects or buildings, living experience of travelling through time and/or space (visit of the castle in XII century and/or link to similar castles in the same region/country...).
- Meta-exhibitions: while visiting a painting exhibition, it is possible to virtually access to other paintings of the same authors, from the same school, from the same period, of the same geographical location... even if these paintings are in the real world spread all over the world. It is also possible to consult, *at the required depth*, information on the painter, the painting technique, the subject of the painting etc. Each visitor can draw his own route through the meta information-space including some of the material present in real life.
- In this area, AmI technologies should play a major role, more especially the advanced interface and display technologies: Multi-sensoriality, Multi-modality, Multi-lingualism, Virtual & augmented reality, 3D displays, Telepresence and the knowledge technologies: Semantic web, Advanced Knowledge Management, Advanced Data warehousing, Converging media.

3.5.3 Cultural Participation

3.5.3.1 “Out-of-house” Cultural Participation and Recreation

The issue is to enhance and personalise the experience of “out-of-house” cultural participation and recreation (film, theatre, dance, music, amusement parks, sport events, manifestations). Pre-/virtual/multi-modal/augmented real life & post-visits would be possible.

The challenge is to provide these services in a user-friendly way, at affordable costs, in order to be accessible by most of the people.

Virtual visits would be enhanced by 3D images, customisation of content and access to hyperlinked multimedia background information. Peer-to-peer file swapping can be part of that. Real-life out-of-house activities would be augmented with context-aware location-based services (e.g. the Lancaster Tourguide) and with adapted incoming and outgoing communications with social networks (Cf. IST Advisory Group 2001, Scenario “Dimitri”). Follow-up experiences can be related to sharing of experiences with other potential visitors and to the selection and planning of new activities.

Transport to and from outdoors recreational activities can be enhanced with intelligent traffic management systems (see Transport & Mobility application area).

3.5.3.2 Creation & Art

The issues include:

- Allowing people who do not master an artistic technique (painting, music...) to express their feelings so as that anybody could be creative;
- Developing new ways of sharing experience and sensations, of co-production and co-creation between artists, “Collaborative Creation Environments” (coined by analogy with “Collaborative Creation Environments”), transforming the process of creation, in specific cases, into a collective process, whereas it is traditionally a solitary process;
- Developing new forms of Art as a result of human-machine and machine-machine interactions, breaking down former categories of art and merging them again.
- The major challenge will be to enhance a very specifically human and not quantifiable quality: feeling and creativity.
- Some visions we may have from this field of application include:
- Using devices strapped to different parts of their body, musicians could activate sounds (such as violins or drums) by moving these parts accordingly; dancers could create visual effects extending their bodies while dancing.

This is a very prospective and open application area. Some artist communities are likely to form the early-adopter “avant-garde”. AmI technologies may enable major breakthroughs:

- Technologies allowing real-time group interaction, visualisation and experiencing of sensations: advanced interfaces & displays: multi-sensoriality, virtual & augmented reality, breakthroughs in input/output.
- Communication and networking technologies to share resources co-operatively.

3.5.4 Media

3.5.4.1 Reading (newspaper, magazine, book)

The issue is to enhance the reading experience by increase access to reading material, anywhere & anytime while preserving and stimulating as much as possible the 'reading experience' that real-world physical paper provides.

Display technologies (e-paper, e-ink, e-book) will be key enabling technologies as well as WAN and advanced data warehousing. Common standards will be important for digital readers. Today for instance, the many competing standards for e-books (dedicated readers, Tablet PC, PDA, etc.) limit diffusion.

3.5.4.2 News & Information

The issue is to provide a multi-modal and mobile access to/delivery of customised cross-media news and information, anywhere and anytime (e.g. breaking news, financial information, transport information, sports results & highlights, etc.). This function could be one of the services delivered by the avatar. Potentially, the formats, styles and modes of delivery could vary according to time, location and activity of the user (context-awareness).

As in the avatar case, one of the challenges is to find the right balance between not enough information (scarcity) and too much information (overload). Part of the answer is to filter and compile not-so-useful or redundant information according to user's needs.

The key enabling technologies include mobile-wireless networks, advanced portable displays, personal information agent, multi-modal interfaces, micro-payments.

Voice-enabled web news, i.e. voice portals that accepts verbal input and produces text-to-speech outputs, would make a difference. They are already under experimentation (e.g. The Frankfurter Allgemeine Zeitung).⁷

⁷ Euromap Newsletter 9 January 2003, http://www.hltcentral.org/usr_docs/Newsletter/archive/Newsletter_20030109.pdf

3.5.5 Entertainment

3.5.5.1 Multimedia Entertainment (listening, watching, interacting)

The issue is to enhance the experience of “passive entertainment” by providing more immersion and/or augmenting the engagement of the user. This last feature could take the form of interactive radio & TV programs, i.e. new forms of participating in broadcast programs. This would be a continuation of virtual presence of people versus SMS or tele voting existing today. At the same time, the control of the user over time, place and mode of entertainment should be increased.

One of the challenge is to allow the user to define him/herself the a right balance between relatively passive enjoyment of multimedia entertainment and interactive engagement in programs and to offer him/her a switching modes between them.

The key enabling technologies will be broadband networks, distributed databases, advanced and 3D displays but also content-based retrieving (music, TV, film) (European Commission, DG INFSO 2002b, Section 2.3.1.8).

3.5.5.2 Playing & Gaming

The issue is to Increase the realism and to add to the excitement of simulation games with immersive experiences/augmented reality gaming/collective gaming (MUD = Multi User Dungeon)/full-body video game interface.

Via mobile technologies, the pervasive gaming could be always on, always available. The avatars created by the gamers, might compete with each other around the clock without human intervention (Sleeth 2002, p. 42).

The challenges are mainly in terms of technology as gaming is already one of the main driver for the development of ICT and is therefore viable in terms of social acceptance and business models. One can more especially mention requirements in terms of communication and networking, interfaces, displays and artificial intelligence.

This steadily improvement of video games and multimedia entertainment have also serious drawbacks considering that the American children and teenagers already spend much less time and efforts at school than watching TV and playing video games. Further social, physiological and medical studies on the effects of long-time immersion into virtual reality are needed. Are these effects going to be more serious with “increased-reality technologies” (sound, 3D pictures, feedback feeling, direct interface with the brain...)? What about the consequences of spending more time into fiction than reality?

3.5.6 Sport & Fitness

The issues are to optimise the time devoted to sport and fitness practise in a modern society, to reduce the risk of sport for senior and/or irregular sport(wo)men thereby contributing to a more healthy society.

The avatar or a dedicated “Sport & Fitness Assistant” could include the functions of health (ECG, blood pressure...) and performance monitoring (instantaneous and average speeds, distance...).

The “Sport & Fitness Assistant” should not require major technological breakthroughs. The requirements would principally be in terms of network and communication technologies and in terms of wearability.

3.5.7 Avatars

The issue is to discharge people under time pressure from many boring and repetitive tasks so that they can concentrate on the most important and enjoying ones.

An avatar, or virtual projection of physical form, would be advanced a Personal Information (& Communication) Assistant (PIA). Having been customised with its users’ profile, an avatar would monitor information sources of interest on its own initiative (pro-activity), scans for instance the offer for leisure (cinemas, concerts, restaurants, shopping, café, hotels, or television programmes ...), filters and compiles the information taking into account the context, constraints and states of mind of the user (context-awareness), and presents the information when required. After the decision of the human user, it would take care of the ordering & ticketing. An avatar is able to an extend defined in advance, to take decisions and initiatives.

It would offer music, games, 'edutainment', adult & youth entertainment on request (sex being a important driver for ICT).

Actually, the avatar is like a red thread which would intervene in most of the functions described below in negotiating on behalf of the human user with service providers.

The right balance between active and passive modes of communication and the way of getting user’s attention are important issues. If it is on a “push-mode”, it can easily be resented as too intrusive, if it is on a purely passive mode, much of the added value is lost.

Some of the key enabling technologies would be: fixed-mobile integration, data-mining, distributed databases, Context-sensitive & affective computing, intelligent agent.

3.6 Health

3.6.1 Introduction

Health, as a general application area for Ambient Intelligent solutions in everyday life, is generally subdivided into three main categories: prevention, cure and care. Although these categories are partly overlapping, and sometimes possess similar kinds of functions, they will be used here as they provide an established and relatively clear framework for analysing the health application area. This means that the primary process is given full emphasis in this study. Secondary processes such as administration, management, logistics and support will only be addressed as far as they are specific to the health sector.

The main subjects in scientific literature concerning ICT & health proved to be e-health, information streams in the health sector (e.g. electronic patient file), and the area of genomics.⁸ As literature on AmI & health proved to be very scarce, it can be said that the application of AmI technologies in the field of health as a whole is still under-researched, except maybe for the topic of continuous monitoring of patients that has received some attention. Besides a lack of visionary documents on AmI & health, there is a definite lack of studies addressing the interdependencies between new technologies and the health care ecosystem.

Due to the notoriously slow implementation of technological as well as organisational innovations in most of the health sector, combined with a small number of sudden disruptive technological breakthroughs, it is very hard to predict any technological trends or trend breaks in this area. It seems more useful to identify the drivers behind innovations in the health application area today.

The main trends driving the application of AmI technologies in the health application area will be discussed in more detail in section 3. The ones that will be considered as driving factors in this study are:

- The integration of health care processes
- Increasing personalisation and context dependency in the health application area
- Accelerating drive towards efficiency
- Overcoming the limitations of time and place
- Health as a lifestyle
- Patient empowerment

⁸ This section is based mainly on the following sources: Durham 2001; Purves et al. 2001; Kunze et al. 2002; Sachpazidis et al. 2002; Pearson and Neild 2001; Kammen 2002; Kiefer et al. 2002; Rijen et al. 2002; Plattform Telemedicine Nederland 2002; Nieuwenweg 2002.

3.6.2 Outline of the Application Area

This study will give some indications of the impact of these drivers on the use of AmI solutions in the health application area and its application sub-areas prevention, cure, care and health management and administration. Also, the contexts of use and the specific social categories are of importance in order to assess how AmI might be used in a certain application sub-area.

Prevention is directed towards informing, monitoring and pre-treatment of people in order to prevent health problems. It is an area in which a lot of actors are involved: the general public, specific social categories with a tendency towards health problems, practitioners, specialists, but also government agencies, pharmaceutical industries etc. Over the last decades, the promotion of a healthy lifestyle has moved from being only a public consideration to a very powerful commercial trend. The healthy lifestyle industry is now also a very important actor in this field. As costs of intelligent applications in health fall and the health application area is moving towards integration of functions and increasing personalisation, prediction becomes a part of prevention too.

Cure is directed towards curing a disease or illness and the short-term recovery process. Activities are a.o. diagnosis, medical treatment, and a usually brief revalidation phase. These activities are mostly undertaken by medical and paramedical staff. Overcoming the limitations of time and place, increasing personalisation and the drive towards more efficiency are the main drivers that impact this field.

Care is a collection of more long-term activities directed towards the recovery process of patients and towards the support of everyday life functions of people in need of long-term attention, such as elderly, handicapped or chronically ill people. Caretaking activities are mainly provided by (professional) nurses, activity companions but also by (non-professional) family members and friends. Drivers such as raising efficiency levels and reducing costs, and objectives such as enabling personal and social autonomy have a large impact upon these activities.

The table below outlines the main contexts of use and some specific social categories relevant to the health application area.

Table 4: Structure of the Health Application Area

Subcategories within the health application area	Contexts of Use	Social Categories
Prevention	<ul style="list-style-type: none"> • Public sphere: e.g. prevention campaigns, public information • Commercial Sphere: e.g. commercial information, lifestyle applications, consult • Private Sphere: e.g. lifestyle, information • Work Sphere: e.g. health and safety provisions on the workforce 	<ul style="list-style-type: none"> • General public • Specific socio-demographic groups or genetically predisposed groups • People in different age groups (children, youth, adults, elderly)
Cure	<ul style="list-style-type: none"> • Public sphere: e.g. emergency services in the street • Commercial sphere: e.g. diagnosis, treatment, monitoring, pharmacy services • Private sphere: e.g. self-treatment 	<ul style="list-style-type: none"> • Patients
Care	<ul style="list-style-type: none"> • Public sphere: e.g. shelters for addicts or socially disadvantaged people • Commercial sphere: e.g. homes for elderly or mentally handicapped or mentally ill people, home care by a nurse • Private sphere: e.g. family care, self care, domotics 	<ul style="list-style-type: none"> • Elderly • Handicapped people • Chronically ill people • Patients in revalidation process • Socially disadvantaged people
Health management and administration	<ul style="list-style-type: none"> • Public/Commercial sphere: personal health files, access rights, health insurance files, selecting providers 	<ul style="list-style-type: none"> • Patients, citizens

In the following sections, the relevant functions within the health application area are listed and described. In addition, a number of existing and emerging (AmI) solutions are indicated.

3.6.3 Prevention

3.6.3.1 Monitoring

Monitoring is the topic most addressed in current literature. Authors see a range of possibilities using ICT and more specifically AmI systems to monitor peoples' health and health-related behaviour, and to provide information or take action based on this activity.

Examples:

- Body sensors with a prevention objective.
- Detectors at the entrance of hospitals or retirement homes against malicious bacilli carried by persons passing by.
- Sensors to alert people with allergies against levels of allergens in the surroundings.
- Lifestyle monitoring: monitoring of and subsequent advice on daily activities and food patterns.

3.6.3.2 Consultation

In most literature consulting a general practitioner (GP) is not part of the curing stage, but of the prevention stage. Obviously, there is a very thin line between consultation and diagnose here. Present-day teleconsulting (in remote areas or between ship crews and a GP) is not a very demanding technology, only requiring a videolink between the GP and the person asking for advice. There is a certain move towards automated consultations, meaning that a consultation is not a person-to-person dialogue anymore, but a person-to-machine or even agent-to-machine dialogue. AmI consulting might integrate AmI monitoring with such remote consulting.

Examples:

- Enhanced teleconsulting (mobile, with additional monitoring information etc.).
- Automated consultations between a person's intelligent agent and a health information database.

3.6.3.3 Information and Education

By their nature, ICTs are suitable for people to receive or look for additional information on health matters. This area consists of peer-to-peer services, pull services as well as push services (one-to-many). AmI provides the opportunities to further personalise information and to make it contextually dependent.

Examples:

- Health websites extended to the public sphere

- Prevention information and education on the workforce regarding health and safety provisions
- Finding out which other member of your health related self-help group is in the neighbourhood and communicating with him or her.
- Barcode scanners recognising products containing (un)wanted ingredients for a specific person

3.6.3.4 Prediction

The linkage of specific personal information with large generic data warehouses is adding the function of prediction to the area of prevention. Prediction is often linked to the development of genomics, which in turn is regarded as a first step towards gene therapy. Prediction is by nature an integrative function, which is highly personalised and may profit very well from AmI solutions.

Examples:

- Intelligent sensing system connected to personal health file predicting near-future health problems
- Restricted access to services depending on genetic information

3.6.4 Cure

3.6.4.1 Diagnosis

To diagnose someone at a distance in most cases a videolink is sufficient. However, there are various cases where more devices are needed. Through the development of “lab on a chip” technologies they will become more widely available. These so-called self-diagnosing devices are needed e.g. for measuring the blood pressure or urine tests. AmI diagnosis might include a number of such self-diagnosing devices.

As was mentioned before, there is a strong link with the “consultation” function. Most examples given there also apply to diagnosis. Furthermore, AmI diagnosis can be extended to include feedback loops from the patient at a later stage, advice of third parties such as specialists or the consultation of medical files or general data warehouses. As patients become ‘empowered’, there will be a greater need to share the information used to make the diagnosis.

AmI will not cause the practitioner to diagnose all patients remotely. The variety and particularities of health problems prevents such a development. Other limiting factors are the unavailability of all possible devices needed to diagnose a patient and the common necessity of the “touch and feel” of the patient to accurately make a diagnose. Related to this latter factor is the common function of a general practitioner as a “social worker”.

Examples:

- Enhanced telediagnosis by tele-immersion (mobile, with additional monitoring information, by different specialists at the same time, being able to manipulate physically a projected image etc.).
- System of self-diagnosing devices on and even inside a patient's body.

3.6.4.2 Treatment and Surgery

Treatment anytime, anyplace will often be restricted by the presence of specialised physical equipment or specific medication. However, high-quality ambient communication and information sharing facilities and ad hoc networking of intelligent devices and medical equipment can facilitate treatment and even surgery at a distance. Also, it is feasible to think of medication dispensers having an uplink to a database or intelligent body systems administering treatment if a number of predefined parameters are being met and registered.

Potential limitations are interference with sensitive hospital equipment, e.g. heart monitoring equipment, and budget related restraints. The latter is caused by initial investments that are likely to be high for health care institutions such as hospitals, and certainly for institutions like nursing homes.

Examples:

- Intelligent implants, e.g. regulating levels of medication
- Ambulant and emergency services supported by ambient information, and being linked to each other in an ad hoc fashion
- Retirement homes or elderly houses using AmI to become virtual hospitals
- Ad hoc networks of medical equipment.

3.6.4.3 Monitoring

Surveillance and monitoring of patients is facilitated by AmI technologies. Medical devices that monitor various health parameters can provide vital data for the curing process. With AmI, constant monitoring of patients condition or their compliance with medical guidelines will become feasible without those patients having to remain under observation in the hospital.

Examples:

- Tagging of patients in a hospital, so that they carry all relevant information about health, diagnoses, treatment, with them at all time
- Having patients 'under observation' without them staying in hospital

3.6.5 Care

3.6.5.1 Monitoring

Again, monitoring within the care process is a vital function requiring AmI solutions. In addition to the aspects and examples mentioned above, there are a lot of additional possibilities for supporting care for the most relevant social categories as described in section 3.6.2. As persons requiring attention are more and more encouraged to live (semi-) autonomously and budgets for professional care are tightened, surveillance and presence info become vital requirements in the caretaking process. Also, so-called assistive technology such as hearing aids, prostheses and heart implants are become more and more intelligent and networked and thus present new possibilities for AmI solutions.

Examples:

- Monitoring of activity patterns, sleeping behaviour, pre-indications of incontinence etc.
- Monitoring of performance and controlling of assistive technology
- Working of assistive technology responding to context, e.g. time of day, mood or surroundings
- Tagging of mentally ill or demented persons

3.6.5.2 Attending

The actual caretaking by professionals or non-professionals is also subject to a number of changes. Professional care will have to cope with budgetary restraints on the one hand, and growing needs and possibilities for administering care to people. Tele-attending and care by non-professionals such as family, buddies and peers are parts of the solution, but are limited in scope. Ambient, permanent care requires intelligent buddies and environments, able to respond to daily needs as well as to emergency situations.

Examples:

- Ambient buddies
- Ambient emergency systems
- Domotics aimed at people with special needs

3.6.6 Support

3.6.6.1 Commerce

There are a number of ‘secondary’ functions within the health application area that are relevant here. They support the selection, transaction, consumption and ‘after-sales’ of health-related services. As information streams in the health application area today are generally

little transparent, AmI may serve to increase co-ordination of health activities, patients' empowerment vis-à-vis organisations within the health sector and/or potential for commercial activities in the health sector.

Examples:

- Universally accessible medical or health insurance file
- Tools for the selection of health service providers

3.6.6.2 Identification and Authentication

Another 'secondary' function is constituted of identification and authentication. This is required to support the countless access rights and privacy issues within the health application area.

Examples:

- Ambient identification and authentication system registering people entering certain areas within a hospital, or scanning people applying for a certain drug or treatment.
- Smart cards with embedded microchips to be used as token for authentication. Parts of a patient's Electronic Patient Record or Electronic Health Record can also be contained on the smart card.

4 Enabling Technologies for Ambient Intelligence Applications

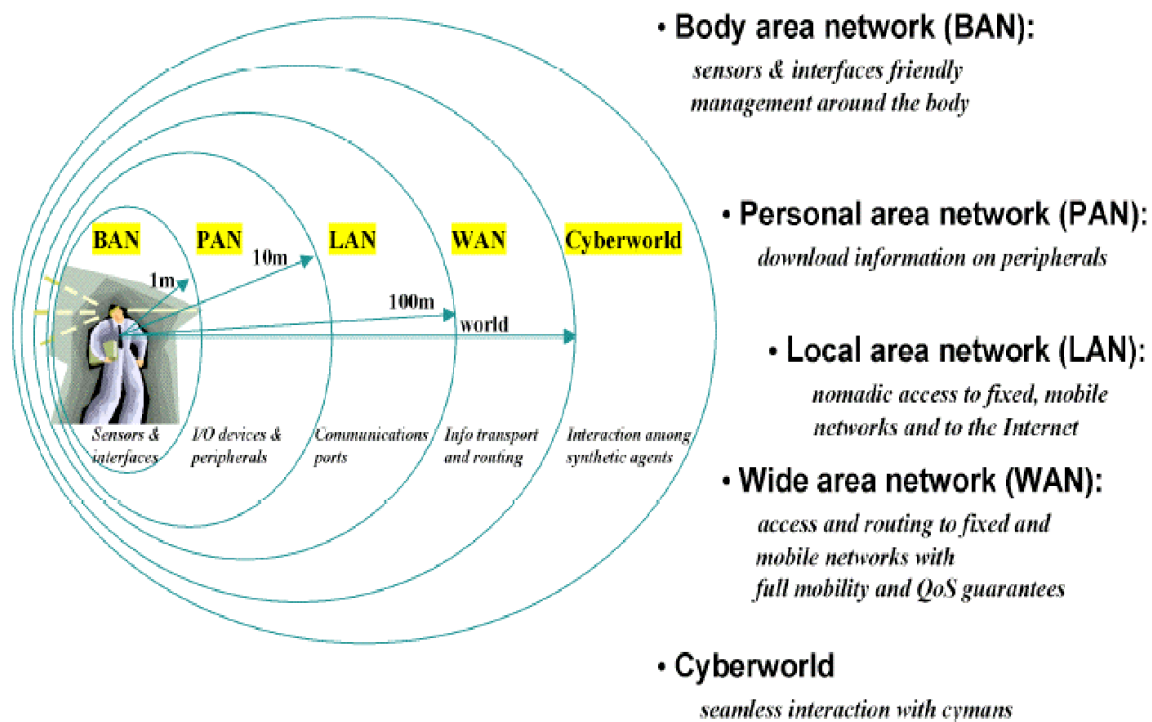
In the same way as Ambient Intelligence has a wide variety of possible applications it relies also on developments in very different fields of technology. Based on the analysis of the IST Advisory Group and complemented by the participants of the Problem Definition Workshop as list of key enabling technologies was compiled. These technologies can be group into ten broad technology areas (BTA). The technology fields analysed in this study are include Communication and Networking, Software, Micro Systems & Electronics (incl. Storage), Displays, User Interfaces, Knowledge Management, Artificial Intelligence, Robotics, Trust and Security, and Power Sources (for the complete list of technologies see Annex A)

For each of these broad technology areas a short description of the state-of-the-art is given. Developments that are important for Ambient Intelligence Applications are analysed and a time frame for the realisation of the respective technologies are given.

4.1 Networking and Communication

It is useful to rely upon a reference model for the interaction between the user and surrounding technologies. The Wireless World Research Forum has developed a conceptual layering of the individual space (see Figure 4):

Figure 4: MultiSphere Reference Model of Communication and Networking Technologies



Source: WWRF 2001

The optical last mile is not so much a technological problem anymore. The commercial use however is uncertain, because of the high investments. **Optical routing and processing** is partly possible already. However, this is a hybrid system. Within four years it might be an all optical system:

- **Wireless LAN** (WiFi or IEEE 802.11 networks) is already commercially available.
- **Wireless Personal Area Networks** (Bluetooth or IEEE 802.15 networks) is already commercially used as Bluetooth 1.1, but the coming three years will see a development to a commercially mature system.
- **Wireless Metropolitan Area Networks** (IEEE 802.16 networks) is already commercially used. However, the WMAN is still under development and will be more widely used in the coming years.
- **Mobile broadband wireless access (MBWA)** for computers, personal digital assistants and other battery-powered devices is the latest development. In the next two years a standard will be developed by the Institute of Electrical and Electronics Engineers (IEEE). It will seek to boost real-time data transmission rates in wireless metropolitan area networks from the dial-up rates of today's cellular phones to a broadband experience of 1 Mbps or more. By providing ubiquitous mobile broadband networking based on cell ranges of up to 15 km or more, the standard will remove barriers for mobile interactive voice, video and data services. The year of commercial introduction will be in the next five to ten years, but the development will continue after that period.
- An **interoperable wireless network** will see more or less the same development as the MBWA. Therefore the bars in the chart are the same.

Another type of wireless networks are formed by the **cellular networks**. 2,5 Generation networks (or **GPRS**) are already being used. Most of the European countries implement GPRS this year or implemented it last year. The 3d generation networks (or **UMTS**) are technically ready. The commercial implementation is expected to begin within 2 years. It is also expected that the technical development will continue during the whole period for which the telecom operators are licensed. **3,5 Generation** and **4th Generation networks** will take longer to enter the market. Development of 3,5 Generation is ongoing, but due to high investment costs it is highly uncertain when it will be commercially used. Parallel to this development lies the **integration of fixed and wireless networks**.

The Internet is changing too. The Internet Protocol version 4 (IPv4) is gradually being replaced by **IPv6**. There are already possibilities for using IPv6, but it will take some years before the supporting infrastructure and devices are adapted to the new standard. **Mobile IPv6**, where mobile terminals and other wireless equipment is connected to the Internet (protocol version 6), is expected to be possible two years from now. After that it will take some time to see a commercial introduction.

To be able to provide location based services, **location technologies** like GPS will be integrated into the wireless networks. In Europe the GPS-system of Galileo will provide the necessary information. From 2010 one expects it to be possible to match precise location information which other location based content.

A third type of wireless networks is **satellite networks**. Developments here are **software telecommunications and software radio**. This will be available soon, but only partly digital. It will take several years to convert this technology into a full digital one. Commercial use is uncertain too. **Improved and dynamic utilisation of radio spectrum** might become available some five to ten years from now. Technical development will continue after that.

Integration of all types of wireless networks might be possible some five years from now. There already is a tendency of wireless technologies that are converging. This process will take quite some time to really develop.

A very promising new technology is **Ultrawideband (UWB)**. This technology is also called Digital Pulse Wireless or Fullerton Pulse Technology. It is based on extremely short energy pulses. Every wave needs a number of Gigahertz of the radio spectrum. By manipulating timing, vibration, polarity and a number of other aspects of the pulses, information can be transmitted. Advantages compared to conventional wireless technology are potential speeds of almost 1 Gbit/s for distances till 10 meters and, within three to five years, some 800 Mbit/s for distances up till 50 to 100 meters. Furthermore the technology is able to position an object with a precision of centimetres. A third advantage is the low energy it uses: up till a 1000 times less than a conventional wireless technology. A last point is that ultrawideband seems to be immune for multipath interference. This means that the complete signal always arrives at the destination, despite of obstacles which may be in the way.

UWB can be used for anti-collision of cars and other machines. Other application areas are home networking (alternative for WiFi) and Wireless Personal Areas (alternative for Bluetooth). However, there is one limiting factor of the development of Ultrawideband. Some critics say that the pulses will interfere with existing and future technology like GPS and UMTS. On the other hand, the Federal Communications Commission has formulated regulation that does not limit the development of Ultrawideband too much. Prototypes using this technology have already been build, but a true commercial introduction will not be expected until five to ten years from now.

A key problem of AmI is how to bridge the barrier between the individual and the network, so realising efficient person-machine interfaces. Achieving ever high degrees of integration between users and AmI applications implies the existence of connections between electronic and telecommunications devices the user wears and the surrounding environment. An advanced network to allow the interconnection of a range of different wearable devices would constitute a **Body Area Network (BAN)** (Dam et al. 2001; Ditlea 2000).

As the BAN has to support interoperability between devices from different manufacturers it is necessary to define a common communications protocol. In this setting a BAN device could be either a complete piece of equipment (for example a cell-phone) or a single component (such as an earphone or a keyboard). BANs do not usually have to communicate over distances greater than 1-2 metres. BANs are not expected to reach enough maturity for practical use before 2010.

4.2 Microsystems and Electronics⁹

Microsystems and electronics play an important part in an Ambient Intelligence environment. Various electronic devices are needed for the proper utilisation of AmI concepts. The future development of these devices is largely determined by advances made in chip design, packaging density, miniaturisation of components, component and functional integration, embedded computing, as well as in such new areas as nano-technologies. Due to the rapid changes in hardware components new analysis and design concepts, methodologies and tools will be needed to develop a platform architecture for the proper design and implementation of devices in AmI systems (see figure in section 4.10.2).

The semiconductor industry has developed tremendously since the first ICs of the early 1970s. Early small-scale integration ICs contained only up to 10 logic gates (NAND gates, NOR gates, etc.) i.e. a few tens of transistors. With medium-scale integration (MSI) the range of integrated logic available added counters and similar larger scale logic functions. Large-scale integration (LSI) packed even more complex logic functions such as the first microprocessors into a single chip. Today very large-scale integration (VLSI) produces 64-bit microprocessors, complete with cache memory and floating-point arithmetic unit with more than a million transistors on a single piece of silicon.

With the advent of VLSI system design then became a matter of defining the functions to be realised using standard ICs and then implementing the remaining logic functions with one or more custom ICs. VLSI made it possible to build a system from a smaller number of components by combining many standard ICs into a few custom ICs. This reduced cost and power consumption and improved reliability.

One of the driving forces in the development of micro electronics is the continuing increase in the density of integrated circuits on a single chip. For over 30 years this development has followed what is called Moore's law. Gordon E. Moore then made the prediction that the number of transistor functions integrated on a single chip doubles every 18-24 months. Even though it is not certain how long this exponential growth will continue it is safe to assume that the general trend concerning density of ICs and the miniaturisation will continue for some time.

AmI is already part of the equipment used in households and in business environments. Computing capacity is provided by software programmable microprocessors in such devices as PCs, notebooks, and PDAs. Embedded systems with computing power are found among others in appliances, entertainment systems, and cars. They are mainly used in applications with limited and clearly defined functionality.

4.2.1 Embedded Systems

Currently embedded systems are commonly realised in one of two technologies: application specific integrated circuits (ASICs) or programmable processors (PPs). ASICs are preferred

⁹ The realization times for Micro Systems and Electronics are based on ITRS 2002; Eggermont 2002; ITEA 2001; Compañó 2000; Cuhls et al. 1998; Münchner Kreis 1999; Pearson and Neild 2001.

for their higher performance and low power requirements. Programmable processors are chosen when flexibility and short development times are important. One of the main differences between ASICs and PPs is the way computations are done in these components. PPs execute a list of instructions sequentially in time with some time-multiplexing of its resources. ASICs typically compute in space and thus take advantage of possible parallel activities.

There are two types of programmable ASICs: programmable logic devices (PLDs) and field-programmable gate arrays (FPGAs). The distinction between the two is blurred. The only real difference is their heritage. PLDs started as small devices that could replace a handful of TTL parts, and they have grown to look very much like their newer counterparts, the FPGAs. An FPGA is an integrated circuit that contains many (64 to over 10,000) identical logic cells that can be viewed as standard components. Each logic cell can independently take on any one of a limited set of personalities. The individual cells are interconnected by a matrix of wires and programmable switches. A user's design is implemented by specifying the simple logic function for each cell and selectively closing the switches in the interconnect matrix. Complex designs are created by combining these basic blocks to create the desired circuit. The programming technology may or may not be permanent. Reprogrammable or erasable devices may be reused many times.

Typical examples for the use of ASICs are: a chip in a doll that talks, chips in satellites, a controller in a washing machine, a chip in a TV control, a chip in an ABS breaking system of a car. Definitely not considered to be an ASIC are memory chips such as DRAM, ROM, and SRAM.

4.2.2 Microprocessors

From their early beginning more than 30 years ago, microprocessors have proliferated into an astounding range of chips, powering devices ranging from telephones to supercomputers.

A microprocessor is essentially a silicon chip that contains a CPU. The terms microprocessor and CPU are commonly used interchangeably. Microprocessors are the heart of all personal computers and most workstations. They also control the logic of almost all digital devices, from clock radios to fuel-injection systems for automobiles.

Three basic characteristics differentiate microprocessors:

- Instruction set: The set of instructions that the microprocessor can execute.
- bandwidth : The number of bits processed in a single instruction.
- clock speed : Given in megahertz (MHz), the clock speed determines how many instructions per second the processor can execute.

In addition to bandwidth and clock speed, microprocessors are classified as being either RISC (reduced instruction set computer) or CISC (complex instruction set computer). RISC systems recognise a relatively limited number of instructions. Until the mid-1980s, the tendency among computer manufacturers was to build increasingly complex CPUs that had ever-larger sets of instructions. At that time, however, a number of computer manufacturers decided to

reverse this trend by building CPUs capable of executing only a very limited set of instructions. One advantage of reduced instruction set computers is that they can execute their instructions very fast because the instructions are so simple. Another, perhaps more important advantage, is that RISC chips require fewer transistors, which makes them cheaper to design and produce. Since the emergence of RISC computers, conventional computers have been referred to as CISCs (complex instruction set computers). There is still considerable controversy among experts about the ultimate value of RISC architectures. To some extent, the argument is becoming moot because CISC and RISC implementations are becoming more and more alike.

To improve hardware performance multiprocessor computer architecture has developed rapidly over the last few years. Ranging from dual processor PCs which are becoming popular in workstations and servers to super-computers with thousands of parallel microprocessors this new architecture has replaced in many cases large mainframe and special purpose computers.

Microprocessors and ASICs designed for small devices and wearable intelligence will have to meet limitations in size, power consumption, and heating effects. The steady increase in performance of microprocessors for PCs has led to larger chips producing more heat and consuming more power. On the other hand developers of microprocessor for portable devices such as notebooks, PDAs, and mobile phones have concentrated to minimise size, heat generation, and power consumption while keeping up with the race for more performance. An example of a microprocessor especially designed for notebooks with low energy requirements is Intel's new 'Centrino'.¹⁰ To achieve its compact size and low power drain gate lengths of 90 nm were realised.

4.2.3 Memories

Semiconductor memories used together with microprocessors or ASICs are usually classified as either Read Only Memory (ROM) or Random Access Memory (RAM). RAM is a data storage device for which the order of access to different locations does not affect the speed of access, except for bursts. It is predominantly volatile memory, meaning all data is lost when power is turned off. RAM is used for temporary storage of program data, allowing performance to be optimum.

There are different types of RAM:

- Static RAM (SRAM) will maintain its data as long as power is provided to the memory chips. It does not need to be rewritten periodically. SRAM is very fast but much more expensive than DRAM. SRAM is often used as cache memory due to its high speed.
- Dynamic RAM (DRAM) DRAM, unlike SRAM, must be continually rewritten in order for it to maintain its data. This is done by placing the memory on a refresh circuit that rewrites the data several hundred times per second. DRAM is used for most system memory because it is inexpensive and small.

¹⁰ See http://www.silicon.de/cls/CSH/04_031202.html

There are several types of DRAM, complicating the memory scene even more:

- Fast Page Mode DRAM (FPM DRAM) is only incrementally faster than regular DRAM. It uses a slightly more efficient method of calling data from the memory. FPM DRAM is not used much anymore due to its slow speed, but it is almost universally supported.
- Extended Data Out DRAM (EDO DRAM) incorporates yet another tweak in the method of access. It allows one access to begin while another is being completed. The performance increase over FPM DRAM is only slight. EDO DRAM must be properly supported by the chipset, but it is the most common type of memory for most users.
- Burst EDO DRAM (BEDO DRAM) is basically EDO DRAM combined with pipelining technology. The result is a much faster EDO memory chip capable of working with faster bus speeds. Support for the BEDO technology is rather sparse. SDRAM has caught on faster.
- Synchronous DRAM (SDRAM) is the developing into a new standard for PC memory. Its speed is synchronous, meaning that it is directly dependent on the clock speed of the entire system. It works at the same speed as the system bus, up to 100MHz. Although SDRAM is faster, the speed difference isn't noticed by many users due to the fact that the system cache masks it. Also, most users are working on a relatively slow 66MHz bus speed, which doesn't use the SDRAM to its full capacity.
- RAMBus DRAM (RDRAM) is a technology being developed by Intel. Its goal is to get rid of the latency, the time taken to access memory. It does this by actually narrowing the bus path and treating the memory bus as a separate communication channel.

ROM is read-only memory that can only be read from but not written to. ROM is used in situations where data must be held permanently. This is due to the fact that it is non-volatile memory. This means the data is "hard-wired" into the ROM chip. Data will remain there and is very secure. A large part of the BIOS of a PC is stored on ROM because a user should not be able to modify/disrupt the information.

There are different types of ROM, too:

- Programmable ROM (PROM) is basically a blank ROM chip that can be written to once. It is much like a CD-R drive that burns the data into the CD. Some companies use special machinery to write PROMs for special purposes.
- Erasable Programmable ROM (EPROM) is just like PROM except that it can be erased by shining a special ultra-violet light into a sensor atop the ROM chip for a certain amount of time. Doing this wipes the data out, allowing it to be rewritten.
- Electrically Erasable Programmable ROM (EEPROM) can be rewritten through the use of a special software program. Flash BIOS operates this way, allowing users to upgrade their BIOS.
- ROM is slower than RAM, which is why some developers try to shadow it to increase speed.

Digital ASICs very often need embedded memory to achieve design goals. The memory blocks required are normally SRAM blocks of 16 to 2048 words with 1 to 36 bits each, or ROM blocks of 64 to 16,384 words with 1 to 32 bits each.

A new type of RAM called Magnetic RAM (MRAM) was pioneered by IBM and is expected to reach volume production in 2004. MRAM combines the best features of today's common semiconductor memory technologies, the high speed of Static RAM (SRAM), the storage capacity and low-cost of DRAM and the non-volatility of Flash memory. This non-volatility carries significant implications for portable equipment such Laptops, PDAs, cell phones, and especially for emerging pervasive computing devices.

Developments predicted for the main semiconductor elements are given in the following table.

Table 5: Summary of projections from the Semiconductor Industry Association road-map (ITRS 2002)

			1999	2002	2005	2008	2011
Technology		nm	180	130	100	70	50
Gate length		nm	140	85-90	65	45	30-32
Density	DRAM	Gb/cm ²	0.27	0.71	1.63	4.03	9.94
	SRAM	Million transistors per cm ²	35	95	234	577	1423
	High-performance logic		24	65	142	350	863
	ASIC logic		20	54	133	328	811
	High-volume logic		7	18	41	100	247
Local clock frequency	High-performance	GHz	1.25	2.1	3.5	6.0	10.0
	ASIC		0.5	0.7	0.9	1.2	1.5
	High-volume		0.6	0.8	1.1	1.4	1.8

Sensors

Sensors are based on a number of technologies including MEMS, piezo-materials, micro-machines, very large scale integration (VLSI) video, and other technologies such as micro-impulse radar.

By far the most important development leading to the rise of sensors are Micro-Electro-Mechanical Systems (MEMS). MEMS stands for a simple concept namely to use semiconductor manufacturing techniques to create analogue devices. MEMS research has been underway for over a decade and MEMS-based devices are already finding their way into the marketplace. The automobile industry is a major consumer of MEMS devices, and is likely to be the single largest early market, as carmakers add them to everything from emissions systems to tire hubs.

Piezo-materials are materials (typically ceramics) that give off an electrical charge when deformed and, conversely, deform when in the presence of an electrical field. Piezos are particularly useful as surface-mount sensors for measuring physical movement and stress in materials. Like MEMS, piezo-materials have been around for some time.

Micromachines are built using semiconductor manufacturing techniques. They are more complex in design than MEMS, incorporating in some instances micrometer-scale gears and other

moving parts. Micromachines exploit the often overlooked structural qualities of silicon: a low coefficient of thermal expansion, high thermal conductivity, a strength-to-weight ratio more favourable than aluminium, and elasticity comparable to that of steel. The process of manufacturing micromachines is in its infancy, and it will be some years before elaborate micromachines will leave the laboratories. Simpler devices will arrive slightly behind MEMS devices.

VLSI Video: Video-cams with all the attendant circuitry required to attach it to a computer as a unit are becoming quite inexpensive. The next generation packages will provide everything on a single chip: the charge-coupled device (CCD), all the circuitry needed, and even the lens will be glued directly to the chip. Cheap video can be used for a myriad of applications, including surveillance, security, and even party games.

Other technologies used in sensors are:

- Micropower Impulse Radar (MIR), a recent invention of Lawrence Livermore National Laboratory which could be useful in such applications as "intelligent" oil dipsticks for autos, handheld wall stud sensors, bulk tank level sensors, land mine detectors, and non-destructive testers for concrete structures.
- Global positioning system sensors are also undergoing radical reinvention, lowering cost and increasing performance. In the not-too-distant future, integrated sensor/GPS modules will be small and inexpensive enough to be placed into courier parcels in order to track the location and treatment of valuable cargoes.
- Cheap laser technology is also rapidly changing gyroscopic technology as ring laser gyros (RLGs) displace traditional spinning-mass systems in aircraft, delivering dramatically increased performance in cheaper, more reliable packages. In the long run, it is likely that advanced MEMS accelerometer arrays will in turn displace RLG technology.

Until recently, CCDs were the only image sensors used e. g. in digital cameras. They have been well developed through their use in astronomical telescopes, scanners, and video camcorders. The increasing number of imaging applications creates, however, a need for optical sensors with improved overall performance as well as additional functions for highly specialised purposes. Due to their technological principle, CCDs suffer from several restrictions in applications where special characteristics such as random access, on-chip data pre-processing or high dynamic range are essential. As an alternative, CMOS imagers have been introduced which employ a conventional CMOS technology for both the detector and the circuitry. CMOS image sensors promise to eventually become the image sensors of choice in a large segment of the market. Image sensors are manufactured in wafer foundries or fabs. Here the tiny circuits and devices are etched onto silicon chips. The biggest problem with CCDs is that there isn't enough economy of scale. They are created using specialised and expensive processes that can only be used to make CCDs. Meanwhile, more and larger firms are using a different process called **Complementary Metal Oxide Semiconductor (CMOS)** to make millions of chips for computer processors and memory. This is by far the most common and highest yielding process in the world (**CMOS** refers to how a sensor is manufactured, and not to a specific sensor technology).

Bio sensors are a neural interface technology that detect nerve and muscle activity. Currently, bio sensors exist that measure muscle electrical activity, brain electrical activity, and eye movement. Bio sensors are electrodes that sit on the skin over the muscle or nerve being sampled. Eye movement, for example, is determined from bio sensors placed strategically on the forehead and under the eyes.

Targeted mainly for medical applications bio sensors have been the subject of intensive research. One goal is to develop an array of chips to collectively monitor bodily functions. Attached to various points of a body these medical telesensors could send physiological data to a monitoring device which could trigger preventive actions in case of problems.

4.2.4 New electronic materials

International Sematech in their annually updated Roadmap for Semiconductors predicts that the development of silicon based electronic devices can continue for at least another 10 years before it reaches fundamental physical limits (ITRS 2002). While traditional semiconductor electronics follows a top down approach (ever smaller devices are created from bulk) the bottom up approach of nano-technology promises „molecular electronic“ devices that are assembled from single molecules.

A number of ways are explored to create devices that can be used to realise logic and storage functions. The most prominent of these ways is the use of organic molecules that can be switched by electric fields. Other approaches use electromechanical switching on the molecular level using C60 fullerenes, photoactive or photochromatic switching using proteins, spin based molecular devices and molecular wires.

All these possible alternatives to traditional semiconductor electronics are still in their very infancy, mainly still subject of experimental research. Even if the fundamental questions are answered there is still the issue of appropriate interconnection and manufacturing technologies for molecular devices. In the long run it is expected that self-assembly could be a possibility to create circuits of a substantial complexity from molecular devices.

In summary experts do not expect that molecular non-silicon nano-electronics will reach maturity within the next 10-15 years (Compañó 2000; Friedewald et al. 2002).

4.3 Software

4.3.1 Large-scale distributed systems

A distributed system is a group of interdependent items that interact to perform a task. The distributed system is large graph of complex objects, linked by references. An object has state and behaviour. Any object can point to any other object, but effective access to an object is

limited by access and concurrency control. The dominant access mode is searching for an entry point into the graph, then navigating the references from there. This kind of architecture is appropriate for interactive and group-oriented tasks, such as co-operative computer-aided engineering.

Distributed systems vary in their degree of centralisation. Traditionally distributed systems tend to be fairly centralised.

The server/client paradigm is the prime example. All essential computation and all services are placed on the server; the client is little more than input/output device, providing little more than the GUI. Other examples of distributed systems are Message Oriented Middleware (MOM), where each system communicates with the others sending messages and Web Services (which are another very important development path). Nowadays fully decentralised systems are gaining interest, as peer-to-peer systems success demonstrates. Such distributed systems have a very large potential especially in the field of scalability and robustness: this simplifies the creation of large-scale distributed systems (Shapiro 1997).

In the recent past peer-to-peer networks like Napster, Gnutella and Freenet have gained great popularity demonstrating how a large-scale distributed system is able to reach planetary dimension, sometimes sharing petabytes of data. Peer-to-peer networks are the best example of large-scale distributed systems.

We can foresee that by the next two-three years large-scale distributed systems based on web services will be available. Standardisation problems seem to be on the way to solution and scalability concerns related to Web Services centralised architecture will be solved by standards like BPEL4WS.

4.3.2 GRID Computing

Grid computing aims at creating a computational grid that may be accessed with the ease similar to electrical power. Grid computing technology has been developed to allow the use of the enormous computing power available in the Internet. Millions of servers have been connected to the Internet and their computational power may be used simply applying distributed and parallel computing techniques. These techniques had been known since a long time and have been applied in this new environment.

Grid computing allows to couple geographically distributed resources and offers consistent and inexpensive access to resources irrespective of their physical location or access point. It enables sharing, selection, and aggregation of a wide variety of geographically distributed computational resources (such as supercomputers, compute clusters, storage systems, data sources, instruments, people). Thus allowing them to be used as a single, unified resource for solving large-scale compute and data intensive computing applications (e.g., molecular modelling for drug design). Users may even express their quality-of-service requirements.

Globus toolkit is middleware platform for grid computing applications and is a de facto standard. Different initiatives of Grid computing have been taken to common workstations all

around the world: when a user isn't using its computer and its screen saver begins working, the computational power of its CPU may be used to analyse the signals coming from the space and collected by different antennas looking for extraterrestrial forms of life (SETI@home project) or to find a vaccine for anthrax. Other initiatives allow users to share computational power.

One of the most interesting paths of development for grid computing is Grid Web services. In this case the computational power is not used for number crunching, but to manage millions of requests to different complex services.

The concept of Web Service, that is typically static, becomes dynamic allowing services to generate other new services, to modify their configurations and to migrate between different servers. Grid computing will probably become quite a mature technology, being available to the market by the next four-six years.

4.3.3 Workflow management

A workflow is the defined series of tasks within an organisation to produce a final outcome. A workflow management system (WFMS) is an application that manages the process assigning tasks to resources as supervisors do assigning tasks to clerks.

Workgroup computing applications allow to define different workflows for different types of jobs. So, for example, in a publishing setting, a document might be automatically routed from writer to editor to proof-reader to production. At each stage in the workflow, one individual or group is responsible for a specific task. Once the task is complete, the workflow software ensures that the individuals responsible for the next task are notified and receive the data they need to execute their stage of the process.

Through to workflow management systems workers are guided in carrying out their job, helped to take decisions and they do not have to make all the tasks that may be automated.

The adoption of a WFMS in an organisation generally requires a phase of business process reengineering (BPR): the internal processes of a firm must be reorganised to take into account the new technology that will be introduced.

Practically all WFMSs include reporting and analysis tools to control the process. For example it is possible to find the productivity of groups and individuals or to set alarms if the number of items to be processed is too high.

WFMS is a mature technology. Different products are available on the market and a lot of firms use this kind of systems. WFMS may be divided into three main categories:

- *Ad hoc* or *collaborative* are generally built on e-mail platforms and are used in professional and administrative areas;
- *Production* are thought to support high volumes and generally work on very simple flows
- *Administrative* which is a cross between the ad-hoc and the production.

Research activity is nowadays focused on process definition interchange. The aim of this work is to develop a process definition language (like XPDL) that will allow the import and export of the process definitions from one platform to another.

Another interesting development in this field is the possibility to make different WFMS co-operate: standards exist since year 2000.

The bigger development in this field is probably related to Web Services. A business application may be seen as the integration of different web services. This integration must be coordinated by a WFMS. BPEL4WS is an example of a proprietary language that aims at doing such an integration. Today there are tools that allow this union of web services with workflows. The first commercial applications will be available by the next one or two years.

4.3.4 Embedded systems

Silicon technology is continuously growing and the complexity of modern chips is so high that we talk about “systems on chip” rather than “integrated circuits”.

Nowadays silicon production may be divided into two big categories: general purpose devices (like CPUs and memories) and embedded systems, designed with particular specifications and destined to specific applications.

A typical embedded system is composed of hardware and software and so it is necessary to use techniques of hardware and software co-design. This means that hardware and software must be thought to operate together since the beginning of the project.

Virtually all appliances that have a digital interface utilise embedded systems. Some embedded systems include an operating system, but many are so specialised that the entire logic can be implemented as a single program.

In 2001 the production volume of embedded systems occupied the absolute majority of the market. On the market are available operating systems and language platforms that are tailored for the embedded applications, such as Embedded Java and Windows XP Embedded. Industrial machines, automobiles, medical equipment, cameras, household appliances, airplanes, vending machines, and toys (as well as the more obvious cellular phone and PDA) are today among the myriad possible hosts of an embedded system.

With the next generation of integrated systems there will be the shift from “systems-on-chip” to *Networks-on-Chip* (NoC). NoC should be able to communicate whether within the NoC itself or with the rest of the world.

Tools and design techniques will grow faster trying to fill the gap between what can be built and what can be designed. On board the chip will be a lot of different functions and sub-systems with different characteristics and design philosophies. Another development perspective is FPGA (programmable logic) that will allow the dynamic reconfiguration of big portions of the NoCs.

It is possible to foresee that by the next three-four years NoCs will be available to the market.

4.3.5 Lightweight Operating Systems

Within last years, between small dumb personal electronic devices, like digital clocks, and high performance devices, like Personal Computers, a new breed of devices began to spread. Such devices cover the intermediate performance gap between dumb and high performance systems, and thus follows the need for specific operating systems, not so heavy like the PC's but close to them in behaviour. An operating system (sometimes abbreviated as "OS") is the program that, after being initially loaded into the computer by a boot program, manages all the other programs in a computer. A lightweight OS is targeted to a specific low performance and small platform; this means that it has reduced capabilities, in order to use few hardware resources, and ad-hoc user interfaces, not necessary based on a keyboard-mouse-monitor paradigm. Lightweight OS's, otherwise, have to fully support real time user interaction as Personal Computer OS already do. Up to date, any lightweight OS must have networking capabilities.

The Lightweight OS taxonomy can be seen from an historical perspective. Up to date, four main families share most of the users' pockets. Symbian is a lightweight OS growing from the mobile phone world. This means that its genesis comes from the experience of a very small OS, used in early mobile phones, growing towards new devices higher performances. PalmOS is a lightweight OS born with the first handheld devices. WindowsCE/PocketPC and embedded Linux are covering the opposite path for Symbian, starting from PC OS' and leading towards lower performance devices.

The OS's presented above, all have networking capabilities, an icon based user interface, multithreading support and a local storage capabilities.

Lightweight OS definition cannot be freezed, but will continue to shift in order to follow hardware improvements of small devices. This means that Lightweight OS's will tend to include current PC OS's features within a couple of years, to include new user interface features like speech recognition possibly in five years, and to include pervasive computing capabilities in a not predictable amount of years.

4.3.6 New and open standards

In the recent past standardisation has gained more and more importance in the IT world. Not only big standardisation institutes (like W3C and IETF) have strengthened their importance but even a lot of consortia have born, trying to define and impose standards related to specific application domains. One of the most important standards, XML, has been introduced by W3C five years ago. Since then a lot of other domain specific standardisation consortia have been created to define XML applications. VoiceXML, for example, is a language for writing vocal applications created by a consortium of firms operating in the vocal applications area. Thanks to this standard every VoiceXML application can be interpreted by nearly every vocal

platform available on the market. The WWW is the best example of the *interoperability* that standards allow: every computer in the world can access data on another one simply because they both use the same standard protocols accessing the network (IP, TCP and HTTP, for example), and because they speak and understand the same language, HTML.

Applications can *share data* using XML, no matters which OS they are working on nor which language they are written in. With the future standards that will be defined it will be possible to *share services* (thanks to Web services family of standards like UDDI or WSDL) or even *computational power* (thanks to grid computing standards).

XML is quite a mature set of standards and is every day used in more and more applications. Web services suffer a little lack in specifications even if core standards are available, while in the field of Grid computing there only are de facto standards.

Internet (that is based on a set of standard protocols) will probably become a big environment, where every resource will be shared and made available to anyone. Sharing of data is already possible. Sharing of services is nowadays possible but it will reach great diffusion only by the next two or three years while grid computing applications will be available by the next three-six years.

4.3.7 Advanced software engineering (robust development tools and platforms)

Software industry has always had the need to develop high quality software. During the last few years software engineering research has changed a little its objectives: reliability and security remained the key aims but the context in which software systems are developed has evolved.

- There is need to have incremental and rapid development tools;
- Development must rely on the reuse of distributed components;
- Applications must be able to evolve, auto configure and modify themselves while executing
- It is no more possible to plan and govern the development process
- Among the new research paths it is possible to find
- software development processes, where high level concepts like features and components are used;
- flexible and configurable development environments that must be able to adapt themselves to offer the best tools available for any particular application environment;
- new models to define application components: what is a component? What shall a component reveal of itself to be correctly usable?

An emerging software engineering technique is model driven development. This is a methodology where all vital parts and aspects of the system under consideration are described with formal models. This technique considers the whole system during its design and for example

recommends the use of formal models for both the business analysis and the IT-system analysis.

Another key feature of model driven development is the support of models at different levels of abstraction, from the high-level business models down to detailed use-case and scenario models for the business execution.

The development process flows from a model to another: every model is the refinement of the previous since more and more details are added to the system specification when moving from problem space to solution space.

One of the first problems that software engineering has to face is the adoption of CASE tools in the industrial process of development. Different CASE tools, referred to traditional software engineering, are nowadays available on the market, even if they are not so widely used in the industrial world. There even are different new ways to define components (like Enterprise Java Beans) and to define their composition (like Jini). On a wider scale new concepts have been introduced for composition/orchestration (like BizTalk, EbXML, ...). This model will probably increase its importance becoming one of the most used application construction models.

Design tools for these new software engineering methodologies will soon be available (in the year 2004). “Several companies have already developed applications using tools that are close enough to the MDA (even though MDA was not formally defined when the work was done)” (OMG). A great adoption of these new techniques will anyway be reached in a longer period of time, probably by the year 2009.

4.3.8 Plug and play

With the advent of ubiquitous computing over the next five-ten years, the computational infrastructure will become more dynamic than it is now. Current middleware technology is not up to handle so a dynamic infrastructure.

A possible solution to this problem is a next-generation middleware, called reflective middleware. A reflective system is able to provide a representation of itself and of its own behaviour. It is even possible to change the description of the system. The system is *causally connected* to the underlying behaviour it describes. “Causally-connected” means that changes made to the self-representation are immediately mirrored in the underlying system’s actual state and behaviour, and vice-versa. In other words a reflective system enables both inspection and adaptation.

Reflective middleware is deployed as a set of elements that can be configured and reconfigured by the application. The internal configuration of the middleware can be inspected and, if necessary, reconfigured in response to environmental changes by the system and application code.

There are a lot of different research projects in this field: researchers at the University of Illinois and Lancaster University have developed reflective middleware systems called Dy-

namicTAO and Open ORB, respectively. There even are researches on for military applications, especially for reliability purposes.

In Europe we have the Component+ project aimed at the further development of Built-In Test (BIT) technology for component-based software engineering.

BIT technology is considered to be a significant extension of OO technology to self-testable and test-reusable software

As these technologies are only at the prototyping stage of maturity, it is possible to foresee that they will be available on the Markey by 2006-2010.

4.3.9 Self organising and repairing software

Access to the network is becoming omnipresent as different and heterogeneous channels are available. As a consequence of the increasing demand of network services, the scale and complexity of current distributed systems is also following an increasing trend. Furthermore, modern systems show an extremely high dynamism, resulting in extremely complex and unpredictable interactions among their distributed components, making it impossible to formally reason about their behaviour.

Examples of these trends can be found in the *peer-to-peer* (P2P) and *ad-hoc networks*. *Dynamic networks* (as often they are referred to) have:

- a large number of users and nodes that influence their behaviour
- extremely variable structure and load
- an extreme variability in topology (nodes joining or leaving the network, crashes and network partitions)

The traditional techniques for building distributed applications, are no more usable in such complex systems: they are only thought to operate in centralised and client server environments. There is the need to use another paradigm in the design of such systems.

What is required is a paradigm shift, capable to compare this complexity explosion and enable the construction of robust, scalable, self-organising and self-repairing distributed systems.

A self-organising software architecture is one in which components automatically configure their interaction in a way that is compatible with an overall architectural specification. The objective is to minimise the degree of explicit management necessary for construction and subsequent evolution whilst preserving the architectural properties implied by its specification.

Different approaches may be followed to implement a self-organising architecture. Research is now being conducted taking as example complex natural systems that may appear unpredictable and imprecise, but at the same time living organisms and the ecosystems in which they live show a substantial degree of resilience. This is called behavioural approach and

takes as example natural systems like social insect colonies, evolutionary systems, mammalian nervous systems, and immune networks.

The underlying idea of this approach is characterised by total lack of centralised coordination. A system consists of a large number of autonomous entities, that individually have very simple behaviour and that interact with each other in simple ways.

Another approach being explored suggests to write the architectural specification of a self-organising system not as a precise description of component instances and their interconnection but rather as a set of *constraints* on the way components may be composed.

It is possible to foresee that commercial applications of self organising software will be available by 2006-2010.

4.3.10 Personalization

On a Web site, personalization is the process of tailoring pages to individual users' characteristics or preferences. Commonly used to enhance customer service or e-commerce sales, personalization is sometimes referred to as one-to-one marketing, because the enterprise's Web page is tailored to specifically target each individual customer. Personalization is a means of meeting the customer's needs more effectively and efficiently, by making interactions faster and easier and, consequently, increasing customer satisfaction and the likelihood of his repeating visits. There are a number of personalization software products available, including those from Broadvision, ResponseLogic, and Autonomy.

Because personalization depends on the gathering and use of personal user information, privacy issues are a major concern. The Personalization Consortium is an international advocacy group organised to promote and guide the development of responsible one-to-one marketing practices. Founding members include PriceWaterhouseCoopers (now IBM Consulting Services), American Airlines, and DoubleClick. The consortium has established ethical information and privacy management objectives; these include, for example, the suggestion that enterprises should inform users about the information being gathered, and the purposes for which it is sought. Profiling engines are generally composed of three modules:

- User profiler: creates a user profile based either on explicit (the user declares its preferences) or implicit (with data mining process) information.
- Assessment of interest: contents are ordered in a list. Each document has a value associated that represents the interest of the user for that content.
- Presentation: contents are organised and then sent to the user.

Personalization tools are currently available in the market and we can consider personalization a mature technology. Users are typically aware of personalization techniques and often appreciate and consider helpful to have Web sites that adapt their contents to better satisfy user's desires.

Commercial products like Ensure XyLoc are available for the personalization even in the wireless environment. Technically speaking, there are no problems to take the personalization

techniques available for ordinary Web sites to wireless environment. Actually profiling algorithms may be simply adapted to work in the wireless environment.

Next objectives in the personalization field are the development of a system that is aware of particular situations that may occur to the user. For example, if a person likes information about tourism, but he is on an hospital, it may be inconvenient to deliver an image with people enjoying themselves in a tropical beach.

4.4 Knowledge Management

Knowledge Management has many definitions, but is generally acknowledged to be the next "age" or revolution, in businesses and organisations.

Gartner Group states that: "Knowledge Management promotes an integrated approach to identifying, capturing, retrieving, sharing, and evaluating an enterprises information assets. These information assets may include databases, documents, policies, procedures, as well as the uncaptured tacit expertise and experience stored in individual's heads" (www.gartner.com). It also includes content management.

Knowledge Management is a very broad umbrella and includes by necessity many people of diverse educational and experiential backgrounds (Newman 1999).

In the Ambient Intelligent scenario study, focused on a technologies/applications, we concentrate the future scenario of KM Broad Technological Area on the fields: Semantic web, Ontology; Standards; Advanced data warehousing, Knowledge Data Discovery; Knowledge Grid (see figure in section 4.10.4).

4.4.1 Semantic web

"The Semantic Web is not a separate Web but an extension of the current one, in which information is given well-defined meaning, better enabling computers and people to work in cooperation" (TopQuadrant 2003; Gartner 2001).

'Web services' is a very first step towards the actualisation of the "Semantic Web". Currently, 'Web services' is only a platform that provides interoperability between software components. However, some vendors have considered embedding context awareness into 'Web Services' to provide some rudimentary form of web intelligence. IDA of Singapore expects intelligent 'Web Services' to take more concrete form in 3 to 5 years, before it eventually achieve the vision of Semantic Web (Infocomm 2002).

The IDC's recently published market analysis, *U.S. Web Services Market Analysis, 2002* (IDC #28493) assert that 'Web Services' will become the dominant distributed computing architecture in the next 10 years and will eventually define the fabric of computing, according to

IDC. 'Web Services' will drive a total software, services, and hardware opportunity in the U.S. of \$21 billion by 2007 and will peak at \$27 billion in 2010 (IDC 2003).

4.4.2 Ontology

Within the next three to five years ontology tools and techniques will offer the unified semantics needed to support dynamic application integration at the enterprise level (Gartner 2001). "By 2005, lightweight ontologies (taxonomies) will be part of 75 percent of application integration projects. By 2010, ontologies using strong knowledge representations will be the basis for 80 percent of application integration projects" (Forrester 2001).

4.4.3 Standards

The standards are indispensable in the KM technology scenario to support interoperability and interactivity between heterogeneous environments. The knowledge shared over the network needs standards to allow the knowledge acquisition, validation, management, dissemination and reuse.

In the Knowledge dissemination future scenario the 'Web Services' security will play a relevant role; this is one area that has to be further developed before reliable 'Web Services' based applications can be implemented universally. XKMS (XML Key Management Service) is a foundational specification for secure 'Web Services', enabling 'Web Services' to register and manage cryptographic keys used for digital signatures and encryption.

The XKMS Specification is currently a Draft Recommendation under the World Wide Web Consortium (W3C, <http://www.w3.org/>) XML Key Management Work Group. Ratification of the XKMS by the W3C is expected to go beyond 2003 (InfoComm 2003).

4.4.4 Advanced data warehousing, Knowledge Data Discovery

The data warehousing developments (advanced data warehouses, OLAP, MDD, KDD) will be leading to new ways of performing decision support and creating executive information systems for data rich environments. They will create a new category of data base and a major set of applications, despite these developments have received almost no attention from academics either in research or in teaching, they are considered a emerging field (Gray and Watson 1996).

In the future scenario the data mining will play a leading role. The "Emerging Trends in Data Mining Through 2010" analysis (Linden 2002) underlines that Data Mining generally will be embedded in larger application suites. Often, other areas, such as good user interfaces or good content management, are simply more important. Advanced users of data mining will continue to look at improved interoperability, and add embedded data mining functions to their portfolio of tools. Oracle, IBM, NCR and Microsoft are all embedding data mining functionality into their databases.

The next generation Web is expected to be based on “Knowledge Grids” that bring together “content” from across the world and that enable easy and relevant searches. The Grid is an emergent infrastructure capable of delivering dependable, pervasive and uniform access to a set of globally distributed, dynamic and heterogeneous resources. A useful abstraction of the Grid architecture is in terms of a three layered model going from data and computation to information and knowledge (Hey 2001).

“Global scientific communities need to perform computationally demanding analyses of geographically distributed data sets that will grow by at least 3 orders of magnitude over the next decade, from the 100 Terabyte to the 100 Petabyte scale” (Avery 2001).

4.5 Artificial Intelligence

4.5.1 Definition of Artificial Intelligence

Artificial Intelligence (AI) can be defined as the simulation of human intelligence processes by machines, especially computer systems and algorithms. The algorithmic techniques include:

- Neural Networks
- Self-adapting Programs
- Meta-Learning
- Genetic Programming
- Intelligent Agent.

We do not aim to review these “basic components” but concentrate on the “first level of applications” which enable the functions, centres of this study. The following applications have been selected:

- Cognitive vision (pattern recognition, fuzzy matching, content-based image indexing & retrieving)
- Speech recognition
- Learning & adaptive systems
- Advanced profiling
- Context-sensitive & affective computing
- Artificial Intelligent Agent

The Broad Technological Area of AI is to some extent cross-cutting most of the other BTA including “Software”, “User Interfaces” and “Knowledge Management”

4.5.2 Cognitive vision

Cognitive vision is the process of visual learning and reasoning that enables machine to make decisions automatically through image interpretation. Within our classification, cognitive vision includes pattern recognition, fuzzy matching, content-based image indexing and retrieving.

A "cognitive vision system" is defined as a system that uses visual information to achieve:

- Recognition and Categorisation of Objects, Structures and Events,
- Learning and Adaptation,
- Memory and Representation of Knowledge,
- Control and Attention.

It includes:

- Pattern recognition,
- Content-based image indexing & retrieving.

4.5.3 Speech recognition

Computers can identify phonemes by breaking them up into frequency and intensity. The task of speech recognition is to map a digitally encoded signal to a string of words. Early attempts of speech recognition were considered as AI works, but now, most of the projects in this field are considered general computer science.

Over the past decade, speech recognition technology has emerged as a success story, evolving into large vocabulary continuous speech systems capable of transcribing naturally spoken sentences on specific topics from typical human talkers. The contemporary systems can recognise fully continuous speech on a 60,000-word vocabulary, with accuracy levels comparable to a human typist (Kurzweil 1999).

Now, the major obstacle in speech recognition is the fuzzy nature of speech: different people speak with different accents and even same person may speak with different tones at different times. Currently speech recognition systems require "training" to be accustomed to the speaker's voice. This can be improved by implementing fuzzy logic in speech recognition systems, and to create feedback-learning loops for the system. However, achieving human-like performance remains difficult and distant (Sweeney 2003).

4.5.4 Learning & adaptive systems

Learning and adaptive systems concentrate on making computing systems adaptive and smart, i.e. that they can modify and eventually improve themselves over time. Both the terms smart and adaptive carry a sense of evolution and learning. Generally three levels of adaptation are identified;

- Adaptation to a changing environment
- Adaptation to a similar setting but without explicitly being ported to it
- Adaptation to new/unknown applications.

The last one is probably the most futuristic one but some of its issues are already being addressed in the field of Machine Learning where a system is built through incremental learning while starting with very little information.

4.5.5 Context-sensitive & affective computing

Ubiquitous Computing refers to a vision of the future information society where humans will be surrounded by intelligent interfaces supported by computing and networking technology that is everywhere, embedded in everyday objects such as furniture, clothes, vehicles, roads and smart materials (IST Advisory Group 2001). One of the early examples of ubiquitous computing applications was locating people and objects. Context awareness renders computing applications to a certain extent smart since they adapt their behaviour based on information sensed from the physical and computational environment. Marc Weiser (Xerox PARC) coined the term Ubiquitous Computing around 1990. He believed it to be opposite to artificial intelligence (Weiser 1993).

Many projects are developed under the term context-aware computing but despite all these initiatives, context is still relatively poorly used in the design of interactive computer systems as a result of a poor understanding what it is and how it can be used (Dey 2001). Moreover, definitions of context are context dependent. The weather, for instance, may be crucial for out-door activities but irrelevant when doing the same things indoors. A challenge is also that many context-aware services assume that the context they use is completely accurate while in reality, both sensed and interpreted context is often ambiguous (Dey et al. 2002).

4.5.6 Artificial Intelligent Agent

Intelligent agents are software that can perform simple tasks. Currently, e-mail filters, search engines can be thought of as intelligent agents. These agents are pre-programmed to recognise patterns and to learn from past experience.

More generally, an intelligent agent refers to computer software that has access to one or multiple, heterogeneous and distributed information sources, pro-actively searches for and maintains relevant information on behalf of users or other agents preferably just-in-time. Developing information agents requires expertise from different research disciplines such as Artificial Intelligence (AI), advanced databases and knowledge base systems, distributed information systems, adaptive information retrieval, and Human Computer Interaction (HCI).

4.5.7 Perspective of Artificial Intelligence

The term “Artificial Intelligence” (AI) was coined at a conference in 1956 in Dartmouth, Massachusetts, US, bringing together the leading lights in the field of robotics and machine research. AI is arguably an example of how sometimes science moves more slowly than may have been predicted.

“What has happened over the last 40-50 years - to the disappointment of all those who made breathless predictions about where AI would go - is that things such as playing chess have turned out to be incredibly easy for computers, whereas learning to walk and learning to get around in the world without falling over has proved to be unbelievably difficult. (...) It has proved very difficult to endow machines with ‘common sense’, emotions and those other intangibles which seem to drive much intelligent human behaviour, and it does seem that these may come more from our long history of interactions with the world and other humans than from any abstract reasoning and logical deduction.” (Humphrys 1997)

AI has until now predominantly been a field characterised by complex research in laboratory scale environments and just only recently has been becoming a part of the landscape of technology in commercial applications. The main drivers of this area includes the entertainment military industry. Sustained very high level of investments into military R&D in the US could result in an acceleration of the developments in this area.

The perspectives for AI in the following decades are much debated. Many argue that the area is not expected to experience radical paradigm shift within the next decade, but a continuous and sustained evolution of technologies that already exist or are in their infancy such as ‘pattern recognition’, ‘fuzzy matching’, ‘speech recognition’. “Classical AI will go on producing more and more sophisticated applications in restricted domains - expert systems, chess programs, Internet agents - but any time we expect common sense we will continue to be disappointed as we have been in the past.” (Humphrys 1997)

Concerning both “Context-sensitive & affective computing” and “Artificial Intelligent Agent” the diffusion of the technologies is therefore expected to occur later, maybe around 2010. Others believe that we are on the verge of another technological revolution (see figure in section 4.10.5).

Ray Kurzweil, a formidable thinker who more than a decade ago predicted the emergence of the World Wide Web and that a computer would beat the world chess champion, forecasts that computers will exceed the memory capacity and computing speed of the human brain by 2020, with the other attributes of human intelligence not far behind (Kurzweil 1999). “By that time paraplegics will be able to walk by using a combination of nerve stimulation and robotic devices. You will be able to choose the personality of your automated computer assistant, who will conduct business on your behalf with other automated personalities. A mere nine years later, you will be able to enhance your intelligence with neural implants. The upshot is that human identity will be called into question as never before, as a billion years of evolution are superseded in a mere hundred by machine technology that we ourselves have created.”

4.6 User Interfaces

Natural interaction research is related to the study and development of systems and methods to allow people to interact with computers and machines in a simple, natural and satisfactory way. Related research fields are computer vision, speech recognition, multimodal interfaces, artificial intelligence, artificial life, human computer interaction, cybernetics, ubiquitous computing, pervasive computing, smart environments, software agents, cognitive psychology and context aware computing, just to mention some of them.¹¹

Multi-lingualism in the context of user interfaces refers to the techniques for providing content, an application or a service in the language preferred by the user. Existing techniques for supporting multi-lingualism mainly deals with facilitating switching between the language used in the user interface (UI localisation) or between different language versions of a service (content). Challenges for multi-lingualism in the future include for example applications utilising multilingual text input or speech interpretation. These applications are closely related to the field of automatic translation.

Multi-sensoriality is a concept where multiple sensors can be used as input for an electronic device. Sensor information can be used by the system in order to adapt to the user or to the environment. Multi-sensoriality can be considered as a more implicit way of using information for controlling a system. Research in this topic is closely related to the field of context awareness.

Multimodal Interfaces use many modalities (e.g. speech command and gestures) at the same time, so they take advantage of the human interaction and perception abilities. Multimodal interaction can, and often does, involve more natural modes of communication than the ones provided by traditional desktop systems. It is about handling a combination of natural inputs to produce output. Multimodality allows a transition from traditional window-icons-menus-pointers (WIMP) interface to more natural ones (Sipilä 2002).

The term Virtual Reality is defined as "a computer generated, interactive, three-dimensional environment in which a person is immersed." There are three key points in this definition. First, this virtual environment is a computer generated three-dimensional scene which requires high performance computer graphics to provide an adequate level of realism. The second point is that the virtual world is interactive. A user requires real-time response from the system to be able to interact with it in an effective manner. The last point is that the user is immersed in this virtual environment. Immersion in virtual reality is usually achieved either by a head mounted display (HMD) worn by users, or by a room-size environment consisting of several projection walls, called a cave. Both the HMD and the caves block out all the external world and present to the user a view that is under the complete control of the computer. The user is completely immersed in an artificial world and becomes detached from the real environment. For a realistic experience, the virtual reality system must accurately sense the user's actions and react in real time. In the case of an HMD, the user's (head) movements must be sensed accurately and the rendered scene must follow with a minimum delay (Vallino 2002).

¹¹ <http://naturalinteraction.org>

Augmented reality (AR) is a real-world environment, which is enhanced with computer-based information or behaviour. This additional information or behaviour can be accessed not only via a HMD, but also by means of any mobile interface or other available device for interaction, including e.g. voice (can be in the environment). The augmented part can be invoked by the user's position, gaze (watching an object), pointing gestures, proximity, touch, spoken name, or explicit selection of an object on a virtual model. AR is a growing area in virtual reality research. The world environment around us provides a wealth of information that is difficult to duplicate in a computer. This is evidenced by the worlds used in virtual environments. Either these worlds are very simplistic such as the environments created for immersive entertainment and games, or the system that can create a more realistic environment has a million dollar price tag such as flight simulators. An augmented reality system generates a composite view for the user.

4.7 Displays

Wearable displays, also called head mounted displays (HMD) have been used in applications of virtual reality and augmented reality. Due to the development of micro- and optoelectronics, wearable displays have become smaller and lighter and thus become an interesting possibility also for wearable and handheld devices such as PDAs and even mobile phones. Development in wearable displays has turned head mounted displays in to eyewear displays using optics to create an image like a heads-up display in your glasses.

The foldable display concept was developed to address the problem of interacting with both simple and complex data and performing a variety of tasks all with the same portable computer.¹² Currently, bendable and rollable screen technology has been limited in part by inflexible transistors. The transistors are needed to control how each pixel on the screen is used to create an image. In an ideal display, a transistor is placed behind each pixel for direct control. But since silicon transistors break when bent, in flexible screens, they are placed on the edges, where they are less likely to be damaged. Such screens can still be flexed, but they do not reproduce moving images such as video very well since the transistors are relatively remote from the pixel they control.

Microdisplays are displays that are so small that magnifying optics are needed to use them. Usually they consist of a CMOS chip which contains a 2-dimensional array of transistors (one per pixel, just like in a TFT display), with on top of every transistor a pixel electrode that also acts as a mirror. In combination with a suitable liquid crystal material and a cover glass this yields a reflective LCD. Microdisplays can be used in projectors, in head-mounted displays, view-finders or other lens-view display systems.¹³

There are two visible areas where development of display technologies can be easily recognised: Computer monitors and mobile terminals (like mobile phones and PDAs). As mobile

¹² <http://www.ices.cmu.edu/design/FoldableDisplay.html>

¹³ <http://www.elis.ugent.be/ELISgroups/tfcg/projects/microdis.html>

terminals have become more capable of processing information, requirements for displays has also increased. The size has increased as well as the performance of displays in terms of resolution and number of colours. The development increases convenience of use and opened a way to a new type of applications (like web browsing in mobile terminal).

A trend towards larger computer displays has been visible for a number of years. CRT-based (cathode ray tube) monitors (and TV-sets) have become big and heavy. One could say that the limit in size has been reached. LCD (liquid crystal display) has been the technology used for displays in notebook and other smaller computers. There are three main advantages in LCD comparing to CRT-displays: size, weight and energy consumption. As LCD-manufacturers are able to produce larger displays in lower prices LCD is likely to replace CRT-based technologies in offices and later homes.

Electronic ink is a new material that will have far-reaching impact on how society receives its information. Electronic ink is a proprietary material that is processed into a film for integration into electronic displays. Although revolutionary in concept, electronic ink is a straightforward fusion of chemistry, physics and electronics to create this new material. The principal components of electronic ink are millions of tiny microcapsules, about the diameter of a human hair. In one incarnation, each microcapsule contains positively charged white particles and negatively charged black particles suspended in a clear fluid. When a negative electric field is applied, the white particles move to the top of the microcapsule where they become visible to the user. This makes the surface appear white at that spot. At the same time, an opposite electric field pulls the black particles to the bottom of the microcapsules where they are hidden. By reversing this process, the black particles appear at the top of the capsule, which now makes the surface appear dark at that spot.¹⁴

4.8 Power Sources

Energy constraints dominate algorithm and system design for small devices. Energy storage has advanced substantially, but not at the pace which is common with silicon-based processing, storage, and sensing. However, over the past 20 years, an AA nickel alkaline (NiCd and NiMH) battery's capacity has risen from 0.4 to 1.2 Amp hours with fast recharging (Commission on Engineering and Technical Systems 1997). This means that the capacity used to grow 5 per cent each year and the energy density reached 1 Joule per mm³. Lithium batteries offer three times higher energy density with fewer memory effects but longer recharge times. For portable devices the ration energy per weight is relevant. Recent polymer-based batteries have excellent energy density that can even be increased to 2 J/mm³ by 2010. It should, however be kept in mind, that some of the substances under consideration are not tolerable for the environment and that their energy density is comparable to that of explosives. With existing technology 1 J of energy would roughly be enough for the transmission of 10 millions bits of data, and it is expected that this value can be enhanced by a factor of 10 in the next years (Doherty et al. 2001), since wireless transmission needs most of the energy for signal processing and amplification. The amount of energy needed is correlated to the size of the chips structures,

¹⁴ <http://www.eink.com/technology/index.html>

which will shrink by a factor of 15 until 2015 (ITRS 2002). The same amount of energy is also enough for 1 billion 32-bit processors instructions, i.e. for 1 second of operation. As all system's layers become optimised for energy consumed per operation, these numbers will increase by at least an order of magnitude and some by several orders.

Meanwhile batteries can be manufactured in a range of form factors and are flexible. Numerous investigations have focused on thin and thick film batteries, and researchers have fabricated tiny, 1 mm³ lead-acid batteries, so one can expect to package energy storage devices directly with logic. The energy demand of electronically implemented functionality and the wish to change batteries as seldom as possible last lead to an intensive search for alternative power sources.

Fuel cells potentially have 10 to 40 times the energy density of batteries, considering just the fuel, but the additional volume of the Membrane, storage, and housing lowers this by a factor of two to five. Furthermore only 20 to 50 per cent of the stored energy can be converted into electricity. For the use as a power source for notebook computers, however, fuel cells are expected to emerge on the market soon, though handling will not be entirely uncritical. MEMS¹⁵ approaches are exploring micro heat engines and the storage of energy in rotating micro machinery. Solar panels remain the most common form of energy harvesting, but numerous investigations are exploring avenues for using the mechanical energy associated with specific applications, such as flexing shoes, pushing buttons, window vibration, or airflow in ducts (Paradiso 2000). This might be a useful power source in the context of specific applications, but only when processing, storage, and sensing devices need considerably less energy than today.

Finally nano technology will offer possibilities for very small power sources such as ATPase Molecular Motors, which would be fuelled by adenosine triosphate. This kind of generator could be precisely attached to sites on lithographed substrates and thus generate energy exactly at the location where it is actually needed (Soong et al. 2000).

Sample battery energy ratings include (Estrin et al. 2002):

Non rechargeable lithium: 2,880 J/cm³

Zinc-air: 3,780 J/cm³ (has very high leakage)

Alkaline: 1,190 J/cm³

Rechargeable lithium: 1,080 J/cm³

Nickel metal hydride (NiMHd): 864 J/cm³

Fuel cells (based on methanol): 8,900 J/cm³

Hydrocarbon fuels (for use in micro heat engines): 10,500 J/cm³

Sample scavenging energy ratings include

Solar (outdoors midday): 15 mW/cm²

Solar (indoor office lighting): 10 uW/cm²

Vibrations (from microwave oven casing): 200 uW/cm³

Temperature gradient: 15 uW/cm³ (from a 10° C temperature gradient)

Another option in solving the energy problem is energy saving. There are still a lot of measures that can be taken in hardware as well as for software in order to use the available energy more efficiently (e.g. turning off system components when they are not needed). Finally it is not necessary that each device must expend a lot of energy for processing or communication. If there are devices in direct proximity that have a larger energy reservoir (e.g. mobile phone) or are even connected to the electricity supply, energy could be attained without physical connection to that device.

Generally all functions that need high-performance computation, large databases or a large memory capacity need not be realised „on the spot“, e.g. within the IT accessories of wearable computing. If such a smart device has permanent access to the Internet, a server can do the necessary processing and data storage. In this case a smart device only needs the energy for communication and display. Such a remote storage is also useful since it prevents loss of data if a user loses his small IT accessory.

4.9 Trust & Security

4.9.1 Privacy, anonymity protection

The term privacy can bear some different meanings. It can be used when referring to the desire to keep communication from being seen by anyone other than the intended recipients, and can also be used with the meaning of ensuring that individuals maintain the right to control what information is collected about them, how it is used, who has used it, who maintains it, and what purpose it is used for. The former definition deals with cryptographic techniques in order to transform exchanged data making them impossible to understand for an interceptor, the latter deals with the infrastructure handling information and communication. Anonymity is a particular service for privacy protection: it ensures that a user (or a host) cannot be identified while making a whatever action in a networked environment. Privacy and anonymity are concepts, but not technologies. This means that they can be provided in various ways, depending on the particular technology or application used. Moreover, this means that privacy and anonymity issues can be afforded at different levels, between data-link layer and application layer.

As stated before, privacy and anonymity do not map over specific technologies or solutions. They are features that can be included in heterogeneous fields, for different purposes. Some examples can be anonymising proxies on the web, whose aim is to hide the IP address of a user asking for a webpage, or anonymous remailers, whose aim is to hide the sender of an e-mail. The ambivalent concept of privacy can obviously be mapped on different applications, discriminating between privacy intended as “confidentiality of communication” and privacy intended as personal information control. An example for the former concept can be represented by the PGP application, which keeps anyone but the intended recipient from reading an e-mail; an example for the latter concept can be digital credentials techniques (Brands 2002).

Privacy and anonymity concepts are so wide, that no generalisation can be made. This means that any issue regarding privacy and anonymity is bound to the specific domain, so the definition of future perspectives is impossible, if separate from the domain. Considering some examples, privacy of location data for location based services regards well known infrastructural matters, and can be achieved without any research effort when a location infrastructure is deployed; anonymity for personalization data means the use of pseudonyms, and this research matter that will require at least three years before gaining some results.

4.9.2 Identity Management Systems

Identity Management is a term referring to a set of technologies intended to afford a basic problem: information about the identity of every actor in distributed systems can be spread among many elements, and used by many applications, so needs to be managed. Many users can interact with an heterogeneous IT infrastructure, and every user can belong to different groups of internal or external people, with different roles and rights. The access management process generates data about user identity, user authentication, access control over every resource and process. Identity management systems attempt to simplify the administration of the distributed, overlapping and sometimes not consistent data about the users of an organisation's information technology systems.

In order to solve problems like user data consistency, user access efficiency, sign-on usability, sensitive data reliability and systems scalability the following solutions can be deployed as stand alone or integrated infrastructure elements.

- Using directories (like LDAP) it is possible to centralise the management of data about users, as well as object like files, resources etc. This means that applications can share data about the users, rather than having each system manage its own users list.
- Web access management tools can handle user identity, authentication and authorisation data on multiple applications using a single web interface. These systems replace the sign-on process on various web applications, typically using a plug-in on the front-end web server. They authenticate users once, and maintain that user's authentication state even as the user navigates between applications.
- When users have multiple passwords, on multiple systems, that expire on different dates, they tend to write them down or forget them. To overcome these problems, it is desirable to provide users with a system to manage passwords consistently across multiple systems.
- Single sign on front ends for legacy systems permit easier access to legacy applications. Security issues should recommend the adoption of legacy single sign on only for a restricted group of corporate users.
- Account provisioning systems attempt to streamline the administration of user identity across multiple systems. They normally include a central facility for managing user access, a workflow system handling system access data provisioning, automatic replication of user records data, load balancing features, automatic creation, change or removal of access to system resources.
- CRM (Customer Relationship Management) systems can be used in order to manage personal profile update.

Future directions of Identity Management Systems will be the extension of IMS beyond the borders of single organisations, and the wide adoption of interoperability protocols for applications, like XML. Some examples for the former can be Microsoft Passport (www.passport.net) or the Liberty Alliance Project (www.projectliberty.org), for the latter can be the Platform for Privacy Preferences (P3P) Project (www.w3.org/P3P).

4.9.3 Digital rights management

Digital media such as MP3 audio or video have become very popular today and will be an important part of m-commerce applications. The major obstacle for digital media distribution is the possibility of making multiple copies of the same content without losses in quality: thus users may access copyrighted material without paying for that. Digital Rights Management (DRM) systems are designed to protect copyrighted material from being copied or accessed without permission. DRM systems include encryption, access control, key management, copy control mechanisms and billing systems.

Watermarking is a key technology for DRM systems and is used to add extra information to multimedia data. This extra information is used for copy control, data identification and tracing. Watermarking must fulfil imperceptibility, security and robustness requirements.

Actually it is not simple to adopt DRM techniques on an open network because it is very difficult to have reliable information about the identity of the users. Mobile terminals instead, offer much more information about users and so DRM techniques may be used with better results. Another advantage of mobile DRM is that mobile devices are potentially less vulnerable to attacks than PCs on an open network like the Internet.

The main drawback of mobile DRM is that causes additional data traffic on the network and requires more computational power for decryption and deciphering. Watermarking methods are one of the main technologies used in DRM. Nowadays we can say that this technology has reached a good level of maturity, but it cannot assure a security level comparable to modern cryptography.

As a concrete DRM solution we can cite TCPA Palladium. Palladium is a software from Microsoft that uses a chip (called Fritz) mounted on the motherboard of a PC to make checks on the authenticity of programs. The majors may also use Palladium to make a DVD or a CD usable a certain number of times. Palladium may even be used to avoid the copy of that CD or DVD.

Palladium specification has been published in 2000 and it is currently used in Microsoft Xbox console.

As we said before, DRM is a reality: it will be progressively introduced on desktop PCs hardware and in the next releases of Microsoft's operating systems. DRM will even be a main component of the future m-commerce applications even if its complexity is still a technical challenge. This problem will become less important with the increasing processing capacity of

the mobile devices, and so we can say that DRM will be technically available on mobile handsets by a couple of years.

4.9.4 Secure transactions & Payments

Encryption

Cryptography is the art of *secret writing*, and is the base technology of nearly all systems used to protect information. A cryptographic algorithm is a function by which a message can be transformed so that others than the intended recipient cannot understand it. The original message is called *plaintext*, the transformed (unintelligible) message is called *ciphertext*, the process that produces the ciphertext from the plaintext is called *encryption*, while the inverse process is called *decryption*. Cryptographic algorithms are usually public, but encryption and decryption processes typically involve a secret value called *key*. This key can be the same for both encryption and decryption, in which case the algorithm is said to be *symmetric* (*secret key cryptography*), or there can be two different keys, in which case the algorithm is said to be *asymmetric* (*public key cryptography*).

Cryptography is nowadays used in all systems that need to transmit and/or store information in a secure way, i.e. assuring confidentiality, authenticity, integrity, etc. Examples of this are web browsers, email clients, virtual private network (VPN) software, cellular phones, and many others.

In the field of symmetric cryptography the emerging standard is AES (Advanced Encryption Standard), which will gradually substitute the old DES (Data Encryption Standard) and 3DES (Triple DES). A new research direction in the field of public key cryptography is *Elliptic Curve Cryptography* (ECC), which promises adequate security levels which significantly smaller keys than those used in traditional asymmetric algorithms; which is very important for performance (especially dealing with devices with limited computing power).

Biometrics

Biometric technologies may be defined as “*automated methods of identifying or authenticating the identity of a living person based on a physiological or behavioural characteristic*”.

The definition says “*identifying or authenticating*” because biometrics may be used either to identify a person in a set of many, with a one-to-many matching process or to authenticate a person that claims to be someone, with a one-to-one matching process. The identification/authentication process may be based “*on a physiological or behavioural characteristic*”: physiological means that the biometric uses a stable physical characteristic to perform its work, while behavioural indicates the analysis of a characteristic like the signature. Two parameters are mainly used to evaluate the performance of a biometric system: False Rejection occurs when a registered user is rejected, while False Acceptance occurs when an unauthorised person is accepted and gains access to protected resources. False Rejection potentially

only causes inconvenience to users, while False Acceptance is an index of the security of the system.

Typology of biometric methods

Fingerprints: it is estimated that the chance that two people have the same fingerprint is less than one in a billion, so we can say that stability and uniqueness are points in favour of fingerprint biometrics. Fingerprints are typically used by police forces and in access control applications. In 1999 about 80 companies were developing fingerprint biometrics.

Eye Patterns. There are two kinds of technologies using the eyes for identification: retina scan is performed using a low power infrared light to take a picture of the rear part of the eye. It has been commercially available since 1985 and most installations have been made to protect military sites: retina scan has a FAR (False Acceptance Rate) near to 0 and a very low FRR (False Rejection Rate). The main drawback of this technique is that the user must fix a target while the system takes the picture. Even a camera 1 meter away from the user may do Iris Scan: this technique is more user friendly and the user must not directly interact with the system.

Hands geometry scan: this is the oldest biometrics being available for more than 20 years and it even is the more commercially successful one. Today more than 10.000 locations employ hand geometry.

Facial features: this is the way every man mainly uses to recognise other people. The facial image to be analysed may be caught several meters away and so this technique is not so invading as the other techniques. The problems come with big databases: facial recognition has shown performance problems, when the number of registered users grows over 10 thousands.

Signature dynamics: the key factor for this technique is to distinguish between the fixed and variable parts of the signature. Typical devices used for this purpose are tablets and wired pens that are currently available on a great number of PDAs. Different products are available since 1986.

Voice Verification is very attractive because of its acceptability by users. Speech patterns are formed by a combination of physiological and behavioural factors. The offered security level is medium. There are two approaches to voice verification:

- Dedicated hardware and software at the point of access
- Dial-up of a PC host using regular phones: this technique may be simply adopted on handheld devices using cellular telephone networks.

As we have seen, most biometric technologies are available since mid '80s and we may consider them mature technologies. A lot of companies are on the biometrics market. According to CardTech/SecurTech in 1999, 80 companies were working on fingerprints, 32 on voice biometrics, 15 on signature and so on.

Research challenges in biometrics is to transfer quite mature technologies to handheld devices like phones. This requires new input devices like wired pens, fingerprint sensors, cameras and DSPs. Most of these components are nowadays available, but the very high production costs are the bigger obstacle to the diffusion of these technologies.

Digital signature

A *digital signature* is a method of authenticating digital information, in the same sense that a written signature authenticates a paper document. A digital signature guarantees that the sender of a message is really who he claims to be (*authentication*), that the message has not been altered by any other entity (*integrity*), and that the sender cannot disclaim a message he really sent (*non-repudiation*). Digital signatures are accomplished by using public key cryptography, so each user must have a public/private key pair. Moreover, there must be a way to guarantee the association between a user and his public key: such a mechanism is provided by *Public Key Infrastructures* (PKI). Smart cards are often used to store private keys when high security is needed.

Currently, digital signatures are not very widespread. Obstacles include difficulty in building PKIs, lack of widely adopted standards, legal problems. Digital signatures are important for e-commerce and, more generally, to build a real “information society”, anyway their adoption will probably be slow because of the complexity (and open issues) of PKIs and the problems concerning their legal validity.

Micro payments

Mobile electronic commerce and multimedia content delivery are expected to be the most important applications for future mobile phone systems. Mobile terminals will so become “electronic wallets” to allow payment of services. Actually, charging systems are usually based on connection time or generated traffic. In the future it will also be possible to buy a service or a content and to pay it by using the phone itself as a wallet. With the term “micro payments” we intend all the small payments needed to buy little services and multimedia contents on the Net. Since it is not practical for individual users to charge small amounts of money to a major charge card, a different method of payment is needed for sites that wish to go “micro”. For example if a user wants to buy an mp3, he may pay with its phone and the revenue can be directly assigned to the musician.

Micro payments must be cross platform and so, if a user wants to visit a Web page that costs 0,10 € with his PC at home, he may pay that amount using the cell phone he holds in his hand. The payment is not done in the same time the content is seen, but later, for example at the end of the current month. Another solution is to have a prepaid wallet, so the user pays before viewing contents.

The key factor for the success of micro payments is standardisation, which is the only way to have wide acceptance. Unfortunately nowadays there is no standard available. Different manufacturers have created their own solution: the different solutions are not interoperable, and so micro payments have not reached the anticipated success. From the technological point

of view no real obstacle faces micro payments, at least on a desktop PC. The real challenge for this technology is the creation of a world-wide accepted standard.

Mobile Electronic Transactions (MeT) is an initiative driven from the most important cellular device producers. The device is seen as Personal Trusted Device (PTD), gaining the ability to handle a wide variety of new services and applications such as banking, ticketing and payments. The approach of this initiative vision is somewhat wider than the micro payments one. MeT has already produced a standard; its latest version (1.1) has been released at the end of 2001.

4.9.5 Dependability

Dependability is defined by the IEC as the collective term used to describe the availability performance and its influencing factors: reliability performance, maintainability performance and maintainability support performance.

Dependability is a concept that may refer to different aspects of a system: from auto diagnostics to the “credibility” of the system to more complex fault tolerance solutions (like the ones exposed in section on self organising and repairing software) after identification and isolation of failures. Base functionalities, like the ability to become aware of faults, are essential to build more complex features, like the ability to find and isolate faults and then to restore the lost functionalities, even with a known performance degradation.

Some hardware dependable technologies are nowadays available and are usually used to detect integrated circuits faults at the end of the production process. The first software dependable technologies are available since 2002, but great research activity is performed both in Universities and enterprises.

The increasing system complexity is reaching a level beyond human ability to manage and secure.

New challenges about dependability concern mobile systems where power constraints limit the adoption of known techniques. It is then necessary to develop innovative techniques that will be part of the whole development process. It is possible to foresee that the first advanced dependable applications will be available between 2006 and 2009.

4.10 Technology Roadmaps

In the following timeline for the technologies the timeframe for a possible realisation is given. In the cases interim milestones are mentioned. The colour of the bars is an indicator for the likelihood that a technology will indeed be realised. Green indicates present developments or extrapolations with little uncertainty. Yellow indicates developments with moderate uncertainty. Red indicates developments with a high uncertainty. Developments which are pure wishes, or mind-opening vision or science fiction from today state of the art are marked in Blue.

4.10.1 Technology Roadmap for Communication and Networking

Communication & Networking	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	beyond	
	Short Term						Medium Term						Long Term							
- optical last mile																				
- optical routing and processing																				
Wireless broadband networks																				
- wireless LAN																				
- wireless Personal Area Networks																				
- wireless MAN																				
- mobile broadband wireless access																				
- interoperable wireless network																				
Cellular networks																				
- beyond 3G																				
Integration of fixed and wireless networks																				
Internet																				
- IPv6																				
- Mobile IPv6																				
Widely available GPS-like systems																				
Satellite networks																				
- software telecommunications and software radio																				
- improved and dynamic utilisation of radio spectrum																				
Integration of all types of wireless networks																				
Ultra Wideband																				
Body Area Networks																				

4.10.2 Technology Roadmap for Micro Systems and Electronics

Microsystems & Electronics (Storage)	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Long Term				2020	beyond
	Short Term			Medium Term												
Networked sensors & actuators																
Bodily sensors																
Hybrid bioelectrical systems (Neurochips with 1 million neurons)																
Hybrid bio/electrical systems (Computer with bioanalogous processing techniques in practical use)																
bioidentification (Fingerprint, iris etc)																
Faster devices (Circuits with less than 1 ps switching time in practical use)																
Fast devices (With new, yet unknown technology, processors will have a 1000 time higher performance than today)																
Fast devices (clock speed of mobile processors)																
Biosensors that can identify single molecules in practical use																
Magnetoresistance technology (non volatile storage (MRAM) with more than 100 Gb in practical use)																
nanotechnology (logic)																
nanotechnology (storage)																
Nano Technology in common use for complex circuits)																
Circuits with self repairing properties developed																
Biological high-density storage in practical use																
Optical Storage Media with more than 100 Gb/cm2 in practical use																
3D-Recording in Polymers in practical use																
Holographic Storage in practical Use																
Opto electronic integrated circuits widely used (delphi)																
Nanosystems that can move inside the body are used in clinical applications																

4.10.3 Technology Roadmap for Software Technology

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Software				Short Term					Medium Term	
Large-scale distributed systems										
GRID Computing										
Workflow management										
Embedded systems										
Light weight OS's										
New and open standards										
Advanced Software Engineering (Robust development tools and platforms)										
Plug and play (seamless and dynamic self-testing, -configuring & -reconfiguring software)										
Self-organising & -repairing software										
Personalization										

4.10.4 Technology Roadmap for Knowledge Management

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Knowledge Management				Short Term						Medium Term				
Semantic web	Web Services tools mature	Implementation WS with of complex	Intelligent Web services		Web services will drive a total of software,	Semantic web enable services will have some type of project ontology								
Ontology	ontology editor, translation, evaluation,		ontology browser, by 2005 lightweight ontologies (to economies) will be part of			merge, evaluation,				by 2010, ontologies using strong knowledge representations will be the basis for 80% of application integration projects /8/				
Standards		by 2004 XMAS standards ratified												
Advanced data warehousing, Knowledge Data Discovery (advanced searching & datamining)	RW portal		Just In Time Knowledge delivery	Content management systems reflecting the growing importance of content in eBusiness /11/		Real-time Knowledge Management, Knowledge data discovery (KDD), Development of personalisation, consumer, interactivity audio-visual portal /services /11/				Structured and multimedia data mining/10/ Nearly half of enterprises with commercial Internet operations will be using digital asset management systems /11/				
Knowledge GRIDS	Flagship Grids (Teragrid, UK National Grid, Commercial	Grid application begin	the access, management and interpretation of a wide data collection is the dominant factor, the data growth valued for the following years is 2005(10 Petabyte) 2010 (100 Petabyte) 2015(100 Petabyte)											

4.10.6 Technology Roadmap for User Interfaces

User Interfaces	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	beyond	
	Short Term					Medium Term					Long Term									
Natural interaction (calm computing, disappearing UI)																				
Multi-lingualism (UI-localisation, ... RT-interpretation)																				
Multi-sensoriality (sight, hearing, touch, implicit information use)																				
Multi-modality (speech, touch, expressions, gestures, voice markups, explicit information use)																				
Virtual and Augmented reality, visualisation																				
Breakthroughs in input/output (brain-brain and brain-machine interfaces)																				
Personalisation (appearance, functionality, ... affective computing, different features)																				

4.10.7 Technology Roadmap for Display Technology

Displays	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	beyond	
	Short Term					Medium Term					Long Term									
Advanced portable displays (foldable and rollable)																				
Microdisplays (Head Mounted displays, micro display arrays)																				
3D displays																				
Mobile terminal-displays (high resolution color-displays)																				
Large Displays (Huge displays, Flat)																				

4.10.8 Technology Roadmap for Power Sources

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	beyond	
	Short Term			Medium Term				Long Term												
Power Sources	100 % Battery		70 % Battery + 10 % fuel				<50 % Battery													
Use of Power Sources																				
Fuel cells in use for mobile devices																				
Batteries with high energy density (200 Wh/kg) in common use			First commercial use																	
PCs are widely used which only need a small battery for one year's operation																				
Ambient Power useful for critical applications																				

4.10.9 Technology Roadmap for Trust and Security Technologies

	2003	2004	2005	2006	2007	2008	2009	2010
	Short Term							
Trust and Security								
Privacy, anonymity protection								
Identity Management Systems								
Digital Rights Management								
Secure transactions & payments (encryption, biometrics, digital signature, micro-payments)								
Dependability (reliability, maintainability, maintainability support), fault tolerance								

5 Function Roadmaps

5.1 Housing

Applications of Ambient Intelligence Technologies in the field of housing have a long tradition since the 1980s (then called Smart Home, Intelligent Home etc.). That's one of the reasons why housing applications will be available commercially or at least as prototypes within the very next years (see figure in section 5.7.1).

Especially applications in home automation and communication can profit from the advanced stage of technical development and dissemination of devices in private homes. First prototypes of AmI based applications for the control of the home environment (e.g. Heating Plumbing Air Conditioning/HPAC, lighting, and doors) as well as for security functions will be available by 2005. After a short introduction phase a diffusion of these applications can be expected after 2008 and 2006 respectively. If home automation is accepted by the users security applications may be an integral part of our everyday life after 2010. Other environment control applications may reach this stage of adoption after 2014.

AmI based communication and socialisation are even closer to their introduction. Applications for Person-to-person and for person-to-community communication will unnoticed complement today's communication means. Since tele-presence is an application that has no widely used predecessor in private households the introduction and diffusion will be somewhat slower than that of the other communication applications.

Their diffusion will very likely follow the same pattern as other innovations in information systems during the last years. That's why these AmI applications will already be a normal part of everyday life by 2010.

In the field of Rest, Relaxation and Entertainment only the Entertainment applications are complementing existing devices in applications. Here first prototypes will be on the market very soon, and a wide diffusion will be reached even before 2010. Applications for Rest & Relaxation and for Refreshing & Hygiene are new and technologically more demanding. First prototypes for both functions will therefore be available only after 2006. If they will find gain a wide dissemination is less a question of technological development but of the users' acceptance of the devices and applications that would be use in very intimate spheres of the private life

Working in the house is become more and more important. Advanced technologies for home working will first take place for Home Office Work. Here a spill-over effect from the introduction of AmI applications in the work space is expected. Therefore prototypes of AmI applications for home office work will be available as early as 2005 and have reached their full functionality by 2008/2009.

Prototypes of AmI application for the support of household and maintenance work will appear a little bit later (2006) and with a higher degree of uncertainty. It is difficult to predict when they may gain wide dissemination in private household because this is again less a question of technology but of user acceptance for totally new devices and applications.

Many of the AmI applications in housing could also be context-aware. However true context-awareness is still a hard problem and a solution can not be foreseen before 2020. That is probably not a limiting factor since most of the applications are offering solutions for urgent needs or at least for the user's comfort. There should be enough added value to make AmI for housing applications a successful technology.

5.2 Mobility and Transport

A large number of applications in the field of Mobility and Transportation will reach the marketplace within a very short time range. This is due to the fact that systems for the individual navigation and (collective) traffic management have existed for some 10 years and will get momentum from the availability of new mobile networks within the next 2-3 years. The figure in section 5.7.2 gives an overview of the roadmap for mobility and transport applications.

In *traffic management* first prototypes of AmI based systems may even be realised until 2005, since they rely mainly on (existing) types of sensors and only need 3G+ networks for a fast transmission of data from the sensors (at fixed places as well as from the vehicles themselves) to a central processing centre. However the success of such a traffic management system depends strongly on the existence of a dense, possibly even trans-national sensor network along the streets. The erection of such a system, however, is a very cost intensive undertaking, that – under today's conditions – goes beyond the possibilities of public authorities. Public-private partnerships seem to be a way to realise a traffic management system as soon as it is technically feasible. This however depends on a suitable business model so that private businesses would actively take the initiative.

The existence of a traffic monitoring and management system in time is crucial for most of the other AmI applications in this field, since they depend strongly on the data offered by a traffic management provider.

Both real-time traffic information for multi-modal traffic as well as travel assistance will be available as prototypes with basic functionality after 2006. They will reach maturity with full functionality around 2010. Individual Navigation Systems are already standard equipment in many top class cars today. In the context of this study such navigation systems are slightly differently defined with personalised and dynamic (real-time) navigation being the most important advancements over today's systems. It is likely that navigation systems with such features will reach the market in 2005 while their full functionality will not be available before traffic management offers its full functionality after 2007.

The developments in safety applications depend mainly on the availability of sophisticated sensors and reliable pattern recognition procedures. It is therefore very likely that these appli-

cations can be realised within a short time with first prototypes by 2005 and a full functionality in 2008/2009. The detection of emotional signals as the basis of even more sophisticated and reliable driver surveillance systems will not be possible before 2011.

The vision of AmI promises context-sensitive navigation systems that autonomously detect the user's intention and offer the best solutions for travel and mobility on the basis of the actual traffic situation. True context-awareness is seen as a long-term goal for Ambient Intelligence, will be reached with a number of small steps. Though navigation systems will become more and more context aware over the next 15 to 20 years, it is, however, very uncertain, what degree of intelligence these systems will achieve. The realisation of context-aware driver surveillance is even more uncertain because manual interventions are not acceptable in critical situations. Therefore safety applications need even more reliable systems for the detection of the user's „real intentions“.

Mobile information and entertainment have already reached a high degree of maturity and are offered as an extra in many top-class vehicles. The realisation of the visions („Multimedia Car“) depends mainly on the existence of suitable display technologies (flat, rollable) for entertainment and of multi-modal user-interfaces for mobile information. Both technologies will likely have reached maturity by 2005, and thus mobile information and entertainment systems will be on the market before 2010.

5.3 Shopping and Commerce

Due to the already advanced stage of e-commerce and e-business all AmI applications in the field of Shopping and Commerce will reach the marketplace within the next ten year. The availability of next 3G+ networks and the technology's potential for more efficient business will be the driving forces for their realisation. The figure in section 5.7.3 gives an overview of the roadmap for shopping and commerce applications.

Electronic Business and Commerce is already a reality today. It will be enriched by the use of AmI Technologies as soon as they are available. This is especially true for new enhanced catalogue services that will be a component of the “smart shopping cart” and rely on the availability of small, cheap and reliable tags after 2004-2005. Order processing systems will be extended with configurator that use data which is transmitted over a wireless network from a central database (e.g. from the manufacturer of a product). First prototypes of this type of applications are likely to be offered when wireless data networks become operational. On the basis of the two prior applications new forms of profiling will be possible that can be used for marketing purpose, especially personalised advertisement. The acceptance and as a result the actual use of these applications, however, will depend from the existence of supporting services for the secure and trustworthy settlement of transactions as well as from means that ensure the privacy of the customers. The latter applications will almost certainly be available by 2007.

Retailing and logistics do not belong to the “private life” in the narrower sense, they will, however, become more important when Shopping and Commerce become supported by AmI

technologies. Shopping environments (store environment and the services provided in the stores, such as real time data processing of purchased items) represent a large investment that will gradually absorb AmI technologies. Since they rely on the existence of a dense infrastructure for back office functions, the first prototypes of AmI based retailing systems will not appear before 2007-2010.

The more goods are bought in virtual places the more important logistics, i.e. the delivery of these goods to the customer's residence (or a place nearby) will be. Secure storage boxes and Collection and Delivery points which are possible logistics solutions for this function may become reality between 2005 and 2009. Another way is the use. The data collected in the distribution processes will increasingly be used for the further optimisation of the logistics functions.

The AmI applications for mobile commerce are further in the future than the other applications in this field. They all rely on the existence of a dense cellular data network and advanced location technologies. While simple mobile information service will become available between 2006 and 2009, location-based services may not be offered before 2008-2011. Simple services matching personal profiles with information about a location will be offered relatively soon, between 2005 and 2008.

Voice technologies and Digital Asset and Rights Management Systems are maybe the most important technologies in the field of AmI based shopping and commerce, the former facilitating the interaction between man and machine and the latter being the basis for sustainable business models. Both technologies have reached an advanced development stage by now and will become part of shopping and commerce applications in 2005/2008 and 2006/2008 respectively.

5.4 Education and Learning

ICT Support of Education and Learning has a long history, but in most cases missed to meet the expectations. On the basis of AmI technologies the vision of user centred education and learning has a fair chance to be realised. The figure in section 5.7.4 page gives an overview of the roadmap for education and learning applications.

Face-to-face education is not the focus of most development activities in education and learning. However this form of transmission of knowledge can substantially augmented when new media become available. Since this form of learning takes place in a fixed place and is conducted by a teacher/trainer it depends mainly from the availability of broadband transmission and suitable means for the presentation of contents (displays, multi-lingualism). First prototypes will therefore be realised between 2006 and 2008.

All other types of education and learning are much more complex, since they also require significant advances in the development of devices, knowledge management technologies and natural interfaces. Since education and learning system do not only from AmI technology but

also from progress in cognitive psychology, pedagogy and andragogy it is difficult to make predictions.

However, in E-learning and E-Training the existing systems will be continuously further extended with new AmI technologies. Prototypes of Systems that incorporate techniques that support personalised and user-centred learning, however, can be expected not earlier than 2006-2008. Since the acceptance and the actual use of such a system is highly uncertain, the wide diffusion can not be foreseen.

Systems for the evaluation, accreditation and certification of knowledge and competencies acquired by the learner will take place in parallel to the development of new electronic learning and training systems. It can therefore be expected that first prototypes will be realised in the near future (until 2005) and the application will mature along with the growing use of e-learning and e-training (until 2009). Evaluation systems need, however, to detect the specific abilities and experience of each learner in order to come up with a comprehensive judgement of the learner's progress. For this purpose sophisticated Artificial Intelligence procedures will be needed. Since these procedures will be realised only in the long term, true intelligent and adaptive accreditation and certification will not be available before 2010.

Digital libraries and museums are new forms of (informal) education and learning that will be made possible by AmI technologies. Since they rely on the vision that any data should be accessible at any place in any form this applications is technologically very demanding, and relies on wireless broadband access, new displays (augmented reality, rollable displays) and natural, user-friendly interfaces. Furthermore advanced knowledge management techniques are needed to provide the needed information with a reasonable intellectual depth to the user. This information should be transmitted real-time and in accordance with the user's location and movements. First simple prototypes of such applications can not be expected before 3G networks are fully operational in 2005. It will last until 2008 before more sophisticated applications will be put on the market and a wider diffusion can start. Applications with the full functionality (instant, personalised and context-sensitive learning) are long term goals. Their realisation is highly uncertain and cannot be expected before the middle of the next decade.

5.5 Culture, Leisure, and Entertainment

Applications in Culture, Leisure, and Entertainment will be one of the driving forces to bring Ambient Intelligence into the marketplace. Though some of the applications will reach maturity only in the long run and others depend more on user acceptance than on technological breakthroughs, Ambient Intelligence will be the basis for many applications before 2010 (see figure in section 5.7.5).

Applications in the field of media and entertainment will be the first ones to be on the market, since the important actors from industry have been developing them for a long time because they are offering the largest number of possible consumers. Today's first generation of digital books will continuously enhanced by AmI technologies, especially in displays high contrast, wireless networking for the instant access to contents. Both will be incorporated by 2006. The

use of foldable and rollable displays as well as power sources with higher energy density after 2009 will make the devices smaller and more convenient to use.

Television and other forms of audio-visual entertainment will also gradually use AmI technologies. Thus television sets will be equipped with large and flat wall-mounted displays by 2010 and with flexible displays by 2015. The ongoing miniaturisation of electronic devices and the development of new power sources will make smaller portable devices possible. Advanced PDAs will be used as the standard device for news reading by 2008.

Gaming will develop as the second important pillar of AmI based entertainment. Here the developments in displays (augmented reality, 3D-displays) and user-interfaces (multi-sensor, multi-modal) in combination with wireless broadband access will turn gaming into an interactive and collaborative experience. While simple forms of online gaming are already available today the transition to this new quality of gaming can be expected around 2010.

The examples mentioned so far complement or substitute already existing devices and applications. If user needs do not change dramatically, they are very likely to gain wide diffusion even if their actual functionality retains some uncertainty.

There are, however, a number of application addressing needs that have not yet been technically supported. Maybe the (economically) most important of these applications is the support of sport and fitness, which has a strong connection to applications in the health sector. Even today sport performance measuring is one of the driving forces in the development of bodily sensors. It is very likely that this will develop into a personal wearable health monitor within the next few years and finally be integrated in more general systems monitoring vital functions.

Another important application is concerned to preserve and organise our cultural heritage and make it available for everyone. The use of digitised cultural heritage may be for educational (e.g. digital museum, see section 5.4) or entertainment purposes. The digitalisation of written materials is a prerequisite for any application in this field and has been pursued for a couple of years. It is expected that these digitised materials will be incorporated in databases until 2005 and that first simple applications will be available by then. Between 2005 and 2007 the databases will be increasingly interconnected and their contents classified, so that it can be generally accessed by retrieval systems. This development will take place between 2005 and 2008 while the completion of the data base (e.g. with multimedia materials) may take as long as 2014. On the basis of this information and enhanced through progress in multi-sensor and multi-modal user-interfaces more sophisticated applications like augmented historical sites will be possible.

Finally Ambient Intelligence technologies allow the support of (active and passive) cultural participation. AmI based out-of-house cultural participation on the basis of virtual and augmented reality may have reached the necessary degree of maturation around 2010, while the general and widespread use of virtual environments will remain a long term goal. In addition multi-sensor and multi-modal forms of interaction together with the possibilities of virtual and augmented reality will allow new forms of creation and art (between 2009 and 2014).

In personal communication avatars acting as personal information assistants will play an important role. They depend, however, on breakthroughs in Artificial Intelligence such as context-awareness and understanding. Since these breakthroughs are very uncertain to predict, only simple types of avatar can be expected to be realised until 2010 while a true intelligent assistant will remain “science fiction” for an unforeseeable time.

5.6 Health

Health applications are the most demanding but in the long run one of the most promising applications of AmI technologies in everyday life.¹⁶ While in some fields first prototypes can be expected within the next 3-5 years, the main wave of health applications and the wide dissemination cannot be expected before 2010 (see figure in section 5.7.6).

Monitoring is the basis for most health applications. Because monitoring depends mainly on the availability of bodily sensors for the registration of vital functions and networking technologies (mainly Body Area Networks for short range transmission and wireless cellular networks for the transmission of the data for processing and/or storage) the first prototypes of monitoring functions for prevention, cure and care will appear only after 2007, while the maturation phase of monitoring will start after 2010 with the availability of reliable BAN technologies. Intelligent and context sensitive monitoring systems will not be feasible before the end of the foresight period due to the high uncertainty of the advancement in the corresponding areas of Artificial Intelligence.

Since all AmI applications for prediction, diagnosis and treatment of diseases need monitoring data the realisation of prototypes of the respective application will not be possible before 2007, a wider diffusion will not occur until monitoring has developed into a mature technology after 2010.

AmI based diagnosis will most likely develop step by step from a simple supportive application to knowledge based automated systems. Prediction will develop from a simple system that gives alert when certain predefined events occur (level of blood sugar exceeded, irregular heartbeat, etc.) to an advanced system that is able to infer a diagnosis from the registered data. This development, however, is dependent from the innovations in automatic diagnosis. Treatment and surgery does not only depend on data from monitoring, but also on the availability of diagnosis data that can be machine processed. That’s why treatment and surgery support lag behind the other applications in the field of cure for about one year.

The remaining health applications do not depend on data from the monitoring of vital functions. Consultation as a function of prevention for instance is already in use, e.g. on ships. Consultation will therefore include AmI technologies gradually when they are available. Since this application depends strongly on visual communication between a patient and a con-

¹⁶ See also Braun, A.; Barlow, J.; Borch, K. et al. (2003). *Healthcare Technologies Roadmapping: the Effective Delivery of Healthcare in the Context of an Ageing Society (HCTRM)*. Seville: IPTS- Institute for Prospective Technological Studies.

sultant/physician there will be pilot systems as soon as broadband networks become available in 2003/04. Widespread use may be reached by 2010.

Health Information and Education Systems are also possible with today's technologies. Based on the development of mobile communication new, instant forms will be developed after 2004. This will deliver real added value, when it becomes possible to match the information with the knowledge about the individual user's physical condition, i.e. when monitoring data is available after 2007. One can think about the inclusion of even more individual data, e.g. from the data about ingredients of foodstuffs.

Attending focuses on alert/alarm systems and robotics (the latter for the handicapped). This is a rather broad function that will become feasible for single vital functions as soon as the corresponding sensors become available since communication does not play such a central role as in monitoring. Therefore first simple prototypes will be realised as early as 2005, while the maturation of the technologies will take place when robotics for health purposes (micro actuators) become available after 2006 and when all functions in the field of health will integrate into a single system after 2010.

AmI technologies will support functions in health management and administration relatively soon. Especially for identification and authentication of medical personnel and patients prototypes will be available within the next two years, while the wide introduction of advanced systems seems possible after 2007. The introduction of AmI technologies for commerce functions does not differ from other shopping and commerce applications (see section 5.3), they will be realised between 2005 and 2008.

5.7 Function Roadmaps

5.7.1 Function Roadmap for housing applications

Application	Key Function	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	>2020
Home automation	Environment control (including but not limiting to hpac, doors, lighting, etc)			First Prototypes	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology
	Security			First Prototypes	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology
Communication & socialisation	Person to person communication		First Prototypes	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology
	Person to community communication		First Prototypes	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology
	Tele-presence			First Prototypes	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology
Rest & Relaxation, Entertainment,	Entertainment		First Prototypes	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology	Diffusion of technology
	Rest & Relaxation				First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype
	Refreshing / hygiene				First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype
Work & Learning	Household work				First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype
	maintenance work				First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype	First Prototype
	Home Office Work			First Prototype	Full Functionality	Full Functionality	Full Functionality	Full Functionality	Full Functionality	Full Functionality	Full Functionality	Full Functionality	Full Functionality	Full Functionality	Full Functionality	Full Functionality	Full Functionality	Full Functionality	Full Functionality	Full Functionality

5.7.2 Function Roadmap for mobility and transport applications

Application	Key Function	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	>2020
Traffic Management	Traffic Monitoring		First prototypes		Full functionality															
	Dynamic Routing		First prototypes		Full functionality															
	Ticketing and Control		First prototypes		Full functionality															
Navigation	Real-Time Information			First prototypes	Full functionality															
	Travel Assistance			First prototypes	Full functionality															
	Individual Navigation			First Prototype	Full functionality															
Safety	Driver Surveillance			First Prototype	Bodily surveillance	Emotional surveillance														
	Vehicle and Environment Surveillance			First Prototype	Full functionality															
	Information		First Prototype	Full functionality																
Mobile Information and Entertainment	Entertainment			First Prototype	Full functionality															

5.7.5 Function Roadmap for culture, leisure, and entertainment

Applications	Key Function	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	>2020
Cultural Heritage	Preservation of cultural heritage	Large-scale digitalisation of written materials			Increased interconnection of databases			Large scale digitalisation of multimedia materials												
	Organisation of cultural heritage				Generalisation of content-based classification and indexation															
	Access to and retrieval of cultural heritage	Online libraries				Generalisation of retrieval of cultural heritage on demand														
	Intelligent heritage and cultural tourism (historical sites / museums / exhibitions)	First generation interactive and augmented reality exhibitions					Multi-sensorial, multi-modal exhibitions			Tourism in some areas limited to Net access				3D exhibitions using holographic displays						
Cultural Participation	"Out-of-house" cultural participation and recreation						Widespread use of virtual reality for education and recreation													Widespread use of virtual environments
	Creation & Art							Multi-sensorial, multi-modal, augmented reality works of art						Computers have humanlike creativity						Direct brain-brain communication of information and feelings

IPTS / ESTO S&T Roadmapping: Ambient Intelligence in Everyday Life

Applications	Key Function	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	>2020	
Media	Reading (newspaper, magazine, book)	First generation of digital books	Electronic Notebook with display contrast as good as paper	Majority of books and publications are online only	Batteries with high energy density allow increased autonomy	Electronic books with foldable and rollable displays	Common use of electronic paper	Portable TV with rollable displays													
		News & Information		Advanced PDA used for news and information	Wide diffusion of interactive wall monitors	Highest-paid movie stars synthetic	Entertainment-on-demand from commercial services widely spread														
	Multimedia entertainment (listening, watching, interacting)	First artificial stars (Lara Croft)				Widespread use of virtual reality for entertainment and gaming															
		Playing & Gaming		Online gaming gains popularity																	
Sport & fitness		Sport Performance Monitor	Personal wearable health monitor	Monitoring of vital functions with body sensors																	
Avatar	Personal Information Assistants	PDA widely used by executives						Breakthrough in terms of context-awareness and decision-taking													"True Intelligent Assistant" able to understand the context, see, hear, touch in a reliable way and act accordingly

5.7.6 Function Roadmap for health applications

Application	Key Function	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	>2020
Prevention	Monitoring					Simple prototypes			Maturation of technology											
	Consultation Information and Education	Pilot Systems	Non personalised services			Personalised Services	Widespread use													
	Prediction					Simple, data-based prediction		Advanced, diagnosing prediction												
Cure	Diagnosis					First Prototype Systems		Partly automated diagnosis												
	Treatment and Surgery						First prototypes													
Care	Monitoring					First simple prototypes			Maturation of technology											
	Monitoring					First simple prototypes			Maturation of technology											
	Attending					First simple prototypes		Maturation of technology												
Health management and administration	Commerce Identification and authentication					Prototypes	Prototype	Commercial Systems												
						Advanced Systems														

6 Enabling and Constraining Factors

Ambient Intelligence refers more to a mind-opening vision of the future information society than to a forecast. Whether this vision or part of this vision will come true depends on many enabling, facilitating, driving or on the contrary hindering or preventing factors. These could be technical or “human” (economic, political, environmental, social and cultural, demographic). A brainstorming session was organised as part the “vision workshop”. The participants, Commission officials or external experts, were asked to select some amongst the most important factors. The factors were cluster and some of the clusters were ranked according to their potential impact and their uncertainties. One of the objectives was to identify the relevant axes which could potentially frame the alternative trajectories of a scenario building exercise. Within this part, we summarize the results of the session and completed by analysis of the relevant literature.

6.1 Technical Factors

Over the 70 factors selected by the participants, 20 were considered to be mostly of technical nature. This means that the uncertainties over the technical developments are seen as very high. This is another way to state and the co-dependencies between technologies are very important.

6.1.1 Trust and Security

The worries over trust and security, dependability, respect of privacy and anonymity are shared by several participants within the "technical factors" cluster as well as within the “Social, Cultural and Demographic Factors” cluster. Both the uncertainty and the impact are rated as medium.

This is particularly important because as our lives, homes, cars, neighbourhoods, cities and other environments become increasingly digitised and connected, more and more personal information will be digitally gathered, stored and possible disclosed to other sources, services, institutions and/or persons. This would include not only basic personal identification data such as age, sex and location but also information and communication content such as events information (past, current and future), working documents, family albums (pictures, video, chat) and other medical and financial records (Beslay & Punie 2002, Punie 2003).

With Ambient Intelligence, the monitoring capabilities of new technologies can even be massively extended beyond what is currently possible (Punie 2003). Addressing these issues will be a core challenge for the future of Ambient Intelligence. For people to feel comfortable with and to trust AmI, it needs to establish an acceptable level of security respecting their privacy and their multiple identities (Beslay & Punie 2002). It is underlined by one participant that it is fundamentally difficult for machines to understand trust which is an intangible asset.

Most of the applications that constitute the vision of Ambient Intelligence in Everyday Life are increasingly connected and may be seen as the “nodes” in the network society (Castells 1996, p. 470). This raises a number of social and legal issues in relation to identity, privacy and security. The AmI system needs to know a lot of personal information in order to act in a personalised, intuitive and desirable way. It is aware of the identity and location of users and communicates this information to other persons, virtual agents, services, devices and objects. People need to be able to control, in one way or another, the nature and amount of personal information that is disclosed about them and need to be able to differentiate this according to the situation and the actors/systems they communicate with. It is clear that peoples’ privacy is at stake here and that these information exchanges need to be secured and managed.

When the web-connected oven downloads the latest recipe it will also reveal the eating habits of the inhabitants of the smart home. Even if this information could be seen as relatively innocent, its systematic collection may form part of the process of building an exhaustive and highly detailed profile of the user, without his or her knowing about it. One of the characteristics of ambient intelligence is exactly its seamless, invisible communication. The maintenance process of ambient intelligence systems will be driven by micro-payments and the user will not be systematically aware of these payments. This challenges the protection of privacy because of domestic networks being interconnected with outside public networks. People and families will have to manage numerous gateways between them.

Domestic networks are thus critical or vulnerable in many different ways. From a legal point of view, it might be argued that domestic network problems fall under the umbrella of the legal definition of the home or domicile as a private space. This is facilitated by its clear geographical location in the home, but in parallel with the car, as mentioned above, there may be a need to extend this in a more dynamic way. Moreover, recent technology trends indicate that web applications, web services and computing resources tend to be shared and distributed, meaning that most probably, the server(s) of the domestic network will use outside computing resources to provide new home services. It therefore becomes increasingly difficult to make a clear distinction between domestic networks and outside, public networks.

Dependability and security of domestic networks also become key issues because of their integration in the management of more and more sensitive facilities. The concept of healthcare at home illustrates quite well this critical situation. In this scenario the health status of the user could be scanned by the ambient intelligent systems of the smart home. The medical records collected would be then uploaded to the doctor who might provide, digitally, recommendations and drug prescriptions to the patient. But what happens if the prescription does not arrive (on time) as a result of network interruptions? Or what happens if other parties intercept a secret medical communication? Moreover, the doctor might be able to intervene directly in people's lives, by influencing the patients' diet (control of the contents of the fridge) or their environment (modifying the temperature and humidity of the house). If people become more and more dependent on the permanent availability of these systems, acceptable privacy and security levels should be guaranteed both legally and socially.

The issue of control by the user has also been highlighted as essential.

- Manipulation & control using ambient systems;
- Negative effects of privacy and security concerns;
- Problematic of the delegation of control to the technology, "Who is in charge?".

AmI assumes everyday live to be very dependent on its technological surrounding so logically, there is a fear for the loss of control. These technologies could easily be seen as 'big brothers'¹⁷. Users should know what is happening behind their backs (Abowd & Mynatt: 51-52) and as noted by ISTAG (2001: 19) AmI should be controllable by ordinary people, i.e. the 'off-switch' should be within reach (Punie 2003).

6.1.3 User-Friendliness

The necessity for AmI to be user-friendly if it is to come true is both relevant for the "Technical factors" and for the "Social and Cultural Factors". However, this issue was more often mentioned under this first cluster. This may signify that for the participants the challenge is seen more as being of a technical nature (the development of user-friendly AmI products and services) than of a social or cultural nature (the perception people have of what is user-friendly and what isn't). Related factors include:

- Dependability, reliability and predictability;
- Usability of technical devices by "non-technical" people;
- Configuration, personalisation, and control by users;
- Friendly (and not diverting) human machine interface;
- Upgradeability, scalability and tailorability

¹⁷ George Orwell, 1984.

- Very simple communication protocols in the home;

It is also stated that the usability and reliability is presently completely insufficient: "too bad right now". Indeed, if technologies do not deliver what they promise, if they do not react in ways they are supposed to react, and do not function when they are needed, then, it will be very difficult for them to be accepted by the public (Beslay & Punie 2002: 21). It is ever more crucial to achieve a high degree of robustness and fault tolerance that with an exponential increase in networked devices and appliances, the probability of failure for any single device increases proportionally (Punie 2003).

Also, we could argue that the AmI vision could potentially challenge current thinking on use and acceptance of ICTs since it addresses some of the issues at the core of the universal access debate, i.e. user-friendliness, relevant (context-aware) services and natural interfaces. The latter for instance envisage human-machine interactions to become more like the way humans interact with each other in the real world (via speech, gesture, touch, senses). It is envisaged that this evolution away from desk-top graphical interfaces could make it easier and faster for everyone to learn to use ambient devices and services (e.g. ISTAG 2002: 29), thereby attracting people who today lack the skills and competences to use ICTs. Marc Weiser (1991) went even further in its belief that Ubiquitous Computing would penetrate all groups in society and thus become universally accessible (Punie 2003).

The vision of AmI assumes that the physical interaction between humans and the virtual world will be more like the way humans interact in the real world. Humans speak, gesture, touch, sense and write in their interactions with other humans and with the physical world. The idea is that these natural actions can and should be used as explicit or implicit input to AmI systems. Interfacing should be completely different from the current desktop paradigm (GUI-Graphical User Interface) based on keyboard, mouse and display. This also means that interfaces should be multimodal, as humans communicate in a multimodal way against machines that typically operate in a single mode. Moreover, with current interface technology humans must learn and understand the computer language; in the future this would be the other way around (Wilson 2001, Abowd and Mynatt 2000)

Haptic interfaces focus on the human sense of touch, i.e. using objects in the physical world to manipulate a computer-generated world. For example, if a user tries to grab a virtual cup there isn't a non-visual way to let the user know that the cup is in contact with the user's virtual hand. Haptic research attempts to solve these problems, via force (kinaesthetic) feedback and tactile feedback. The former is for instance used in games (e.g. steering wheel) while the latter deals with the devices

that interact with the nerve endings in the skin which indicate heat, pressure, and texture¹⁸.

Tangible interfaces focus on everyday objects. Ambient displays are everyday objects used for information display without interrupting the user or without a deliberate search attempt from the user. They are abstract and aesthetic peripheral displays portraying non-critical information on the periphery of a user's attention. The goal is to present information of secondary importance, hence non-critical, without distracting or burdening the user. Future research should however not only concentrate on designing ambient displays but also on evaluating its effectiveness. Very little is known about this (Mankoff et al. 2003; Wisneski et al. 1998).

With ambients, the physical environment becomes an interface to digital information rendered as subtle changes in form, movement, sound, colour or light. Commercial ambients are already on the market. The Ambient Orb for instance is a small globe, wirelessly connected, that changes colour according to users' preferences for monitoring custom stock portfolio or receiving local weather forecasts (www.ambientdevices.com).

Previous efforts have focused on speech input and pen input but it was very difficult for these interfaces to handle robustly the errors that naturally occur with these systems. A difficult problem for natural interfaces, especially when used for recognition-based tasks consists of the mistakes and errors that occur. Completely eliminating errors may not be possible but recognition accuracy does not seem to be the only determinant of user satisfaction. Even humans make mistakes when dealing with these same forms of communication (e.g. handwriting recognition). Rather the question is how to handle occurring errors in ways that are acceptable for users (Abowd and Mynatt 2000).

There is a huge amount of work undertaken in natural interfaces. A major challenge for multimodal interfaces consists indeed of integrating stand-alone graphical, aural, speech and tactile interfaces. This is crucial, not only for multimodal interactions with computer systems at a particular moment, but especially also for seamlessly migrating and adapting these to different user environments.

In relation to displays, ISTAG distinguishes long-distance entertainment type of interfaces and short-distance mono-personal interfaces. Today, the former consists usually of an infrared remote control, in reality of a proliferation of these controls, and a game pad. They are used for interactions at more than 1 meter from the screen. The short-distance mono-personal interface is today dominated by the personal computer GU Interface (with a keyboard and a mouse). In the future, ISTAG

¹⁸ <http://haptic.mech.nwu.edu/>

believes that most interactive applications will have to deal with both long-distance and short-distance interfaces and insists that these interfaces need to be easy to use by people of all ages. Using existing personal computer interfaces has the risk of creating a "digital divide", as these solutions are too expensive and too difficult to learn (IST Advisory Group 2002).

Displays do not follow Moore's law and they therefore represent a large part of the total cost and power consumption of most appliances. Displays are often the blocking point for a massive deployment of new applications.

In the home, there is a need for several types of display, all of them being flat displays:

- Large (50 cm to 1 meter diagonal) with high resolution (1,000 lines) for multi-person viewing of TV, movies, images and games. Relevant technologies are plasma and projection LCD. The major issue is cost.
- Medium size (40 to 50 cm) but still high-resolution displays for desk-top applications (such as a PC monitor) and mono-personal entertainment. The relevant technology today is LCD.
- Small, low-resolution displays with a broad range of sizes, resolutions, colour or monochrome to be used in nearly all home appliances (white goods, home control, audio systems). Relevant technologies are OLED, PLED (IST Advisory Group 2002, p. 29).

For the personal environment, low power and lightweight displays are important. Also, multi-modal interfaces that include gesture recognition and input from sensors to support speech and sound driven systems are crucial for people moving around. Personal interface management systems are to be considered as well, to enable personal devices to interact with each other and use the interface devices available in different environments, such as the head-up display on the car windscreen or the office wall (IST Advisory Group 2002, p. 44).

Breakthroughs in input/output devices including new displays, smart surfaces, paints and films that have smart properties are regarded as fundamental to enable people interacting with their intelligent environment (Ducatel et al. 2000). Widespread implementation of interfaces with multiple input/output mechanisms is only to be expected between 2010 and 2020 however, not only due to technical challenges but also due to uncertainties in relation to return-on-investment and to consumer acceptance. Moreover, the computer industry's track record in improving the ease of use of their applications is not particularly great (Wilson 2001).

6.1.4 Relevance

However the key question of the application on “Everyday Life” remains. Even if all the participants to the workshop are to some extent involved in research or policy on future IST, they are not completely certain that AmI is actually relevant to everyday life, that it is going to increase the well being, make life easier or more attractive. It is stressed by several of them that the design and development of AmI products and services have to be driven by the relevance for the general public and that the applications have actually to be useful and/or engaging.

The noticed shift in the AmI vision towards 'human centred computing' with an emphasis on user-friendliness and user support for human interactions claims to place people at the centre of future development. The whole purpose of function-oriented investigation on AmI is to understand how everyday tasks can be better supported and enhanced by the introduction of ubiquitous technologies (Abowd and Mynatt 2000).

In a critical essay on Ubiquitous Computing, Arraya notes a striking imbalance between the marginality of the enhancement proposed (e.g. elevator stops at right floor, rooms greet people by name, automatic coffee, etc) and the complexity of the computing infrastructure required to achieve it. Although it may be tempting to discard the marginality as if it were only an impression produced by initial scenarios, it has, according to Arraya, a more fundamental character, i.e. "it constitutes an attempt at a violent technological penetration of everyday life" (Araya 1995, Punie 2002).

We would not go as far as Arraya argues, but it raises the question how AmI could contribute to the quality of life. Think for example of the unexpected success, both for companies and for consumers, of SMS (Short Messaging Service). When the first test messages were sent ten years ago, if you would describe its function, it would probably have looked marginal or even anecdotal as well, e.g. sending a short 'Merry Christmas' message, especially in relation to the "quality of life". Finally, SMS encountered a huge market. Does SMS today improve the "quality of life" of its users? How could we measure "quality of life"? Users seem to regard it, in any case, as fun, convenient, discrete and cheap.

It is always difficult, when imagining early uses of new technologies, to assess their usefulness and potential impact, especially as new uses and unexpected uses emerge when the technology already exist, as was the case for SMS.

6.1.5 Other Important Factors

The need for interoperability together with the need for the definition of global standards is highlighted as one of the most important factor for the realization of AmI. The impact is estimated to be high as well as the uncertainty.

The availability of adequate power sources is identified as one of the major enabling factors for the realization of AmI with both high potential impact and high uncertainty. Also the trade-off is made explicit between one side ambient / autonomous or micro-power sources with a reduced set of functionalities and on the other side more functionalities with a higher energy consumption.

The ability of telecommunication technologies and infrastructures to respond to the needs and solve the congestion is seen as one of the major enabling factors for AmI. It is also brought up that exchanging image and video sparks huge increases of bandwidth needs.

Others factors are related with the software development technologies:

1. Distributed Systems Architecture;
2. Self configuring networked embedded systems;
3. More efficient development of software: the development of software does not follow an exponential law and is becoming an increasing part of the product price. It may become one of the bottlenecks;

The need for low cost sensors is brought up.

The need to provide adequate maintenance for AmI systems is also mentioned.

Overlapping the “economic factors” cluster, the factors of cost and affordability are mentioned several times.

6.1.6 Potential Breakthroughs

The wild cards could be breakthroughs from the application of biology processes for computing, from the understanding of human cognition and reasoning (“Converging Technologies 2002”) or the application of neuroscience application to artificial life (“Futures 1999”), from the elucidation of brain mechanisms for logical reasoning (ISTAG 2001).

Far away and highly controversial milestones are that between 2004 and 2020, processors could 1000 times more powerful than 2003, with new yet unknown technology (Münchner Kreis) or that by 2020 or beyond computers could exceed the memory capacity and the computing speed of human brain (Kurzweil).

However, these long-term and highly-uncertain developments were barely mentioned by the participants.

6.2 Human Factors

6.2.1 Economic Factors

The importance of developing successful business models is emphasized by many participants of the vision workshop. The impact and uncertainty are estimated to be medium to high, especially concerning return on investments.

This issue also encompasses concerns over price and affordability as well as the needs for having adequate speed of market take-off (early adopters) and then critical masses of users. This is particularly challenging for companies as the imperative needs for personalisation and customisation are also expressed (“mass-customisation”).

For AmI to succeed, radically new products and services have to be developed. This is estimated as a medium-uncertainty but high-impact factor.

In particular, “Emotional Products” are mentioned. The idea is to encourage consumers to buy product on an emotional impulse rather than from a carefully-considered and rational decision, thereby paying more for them.

The emerging market could change the state of affairs with China and India possibly becoming massive solvable markets for IST goods in the medium term (2008-12).

A global electronic currency could be established in the same time horizon, tremendously boosting the online commerce.

6.2.2 Political Factors

Politics and geopolitics factors play an important role in the realization of AmI and different factors could boost the developments of radically innovative AmI technologies and products. In particular, were mentioned:

- Concerns over security more especially in the public places but also at home and security of the children and teenager;
- Worries over terrorism;
- Sustained high level of investments into US military R&D.

On the other hand the investments on new technologies may be dropping because of world-wide economic crisis or repeated crises.

The concerns over increased criminal and terrorist activity on internet are very present in the prospective literature. However they were not mentioned by participants as factors likely to influence the realization of AmI.

Overlapping the “economic factors” cluster, the European interventions, subventions, decisions and regulations in the field of IST are mentioned as a medium-to-high-impact and medium-to-high-uncertainty factor. The fragmentation of the policies and levels of decisions is a problem. A strong political will to reinforce EU technological independence may be an asset for IST. It was also mentioned that Ambient Intelligence is a relatively easy concept to sell to policy-makers and public actors and is indeed the European Commission vision of the IST future.

Another important issue is about the control of the global infrastructures and services. Power shifts away from the centre are likely to occur.

The wild card in this cluster could be a splitting of the European Union. This is found to be an highly unlikely (and undesirable) event which would potentially have medium to high impact.

6-2-3 Environmental Factors

“Environment” is first taken in its “global meaning” encompassing pollution control and sustainable development. In this case, the effect of environmental factors on AmI is ambivalent. On one side new regulations on better control of impacts and recycling of ambient systems may impact IST industry and therefore AmI.

On the other side, products based on AmI technologies have a high potential for contributing to environment monitoring and protection. This is mentioned for instance in the context of the industrialisation of China which is causing major damages to the environment.

Overall, the uncertainty is estimated to be low and the potential impact medium to low.

The concept of “environment” can also be understood as the surrounding of people, home in the everyday life. In this sense, many factors are important for the success of AmI. AmI products /services should be / have:

- Healthy;
- Stress-less;
- Near zero power consumption;
- Embedded in Environment;
- Aesthetic Resonance;

- In Harmony / Contact with the environment.

6.2.4 Social, Cultural and Demographic Factors

The social and cultural values and trends framing and shaping people's life are crucial for AmI because they ultimately condition the acceptance or refusal of the new technologies.

Factors correlated with the problematic of universal access / digital divide / techno-inclusion versus techno-exclusion come also high on the agenda:

- Tighter constraints over user friendliness for less-able people such as elderly, disabled, children, lower-educated and poorer people;
- Needs and capabilities of young people versus those of the seniors;
- First world versus Third world;
- Different needs in Central and Eastern Europe;

The emergence of "mixed" or "mosaic" society is mentioned including trends such as end of life employment, individualism, diversity, mobility, choice of personal lifestyles ... The increasing importance of the local dimension (local or specialised communities, region...) is also strongly expressed. It is mentioned that there is a new paradigm of geography where non-local users may have to use geographically-constrained products / services (town, region, country).

Research¹⁹ also confirms that the digital divide is not just a question of access to telecommunications and ICTs services (e.g. Internet) but also of skills, competences, appropriate content, access to the necessary resources (e.g. time and money) and different ways in using ICTs.

The oscillations between on one side consumerism and high demand for IST goods and on the other traditional habits and values, "back to nature" are pointed out. The uncertainty over which side is going to dominate during a specific period is high. Global backlashes against the new technologies are possible, even from well-educated and well-off people, not unlike what is happening with GMO. This could be the case if relevance appears too marginal compared to the investments required to master the new functions and the intrinsic risks of these technologies.

Another overwhelming issue is the ageing of the population which is evaluated as having a low uncertainty and a medium to high impact. This could mean a slowing

¹⁹ See for instance Wyatt et.al. 2002; Gurova et.al 2001, but also www.digitaldividenetwork.org and other EMTEL Deliverables on inclusion/exclusion (www.emtel.org).

down of S&T developments in developed countries and world-wide. On the other hand it will certainly boost the development of specific products and services.

On the positive side it is estimated (Pearson 2000) that up to 90% of people in advanced nations could be computer literate in the mid-term (2009-12) and that in not such a long term (2020) 75% of the world population could use Internet. This would tremendously boost neighbouring IST products and environments including AmI.

6.2.5 Inclusion

6.2.5.1 Social Participation

The shorter-term issue is to enable the remote and nevertheless effective participation of participants to community life, even if they are not in the geographical location. This may allow people who are travelling frequently to play a more active role in social life. In a longer term, new forms of participation could emerge.

Participation takes different forms. Traditional participation in politics, union, religion can be enriched by e-consultations, voting or new forms of democratic consultations, referenda (e-government). New forms of participation such as involvement in human rights or environment NGOs, etc would also benefit from e-participation. The local community life (sports, culture, education, events, etc.) would also be supported and enhanced by the new AmI technologies.

Interfaces and displays may be the key enabling technologies. Telepresence, if and when's feasible, would be a major breakthrough.

As previously, in-depth socio-economic research is needed to precise the needs, the concepts, and the feasibilities (social, economic, legal, technical).

6.2.5.2 Increased Autonomy

The issue is to increase the autonomy of disabled and elderly people so as to enable them to play a more important role in society. The challenges come from the context of ageing population, social security deficits and labour-scarcity. A low user cost is therefore a key factor of success.

Moreover, the functions and instructions for use should be based on the real needs and the requirements in terms of user-friendliness are very important.

6.2.5.3 Improved Social Cohesion

The issues is to improve the fate of the less well-off people in our societies such as the illegal immigrants, minorities, poor, homeless, drug-addicts... One focus direction is to increase the accessibility of relevant information and services.

The challenges are enormous considering that:

- In certain cases, there has been no kind of any previous contact with computers or ICT, in other cases the relation with technologies is radically different (immigrant communities use a lot telephony on IP and satellite TV);
- Neither can it be assumed that the most distressed people have any willingness to participate in any kind of technology-based activity or process;
- What these populations need the most is human contacts and AmI cannot substitute for them.

Here the key factor for success is the human-based functions and instructions for use and user-friendliness. A low user cost would also be decisive.

The fundamental question remains: do AmI technologies have the potential to “make the difference” by taking some of them aboard?

6.2.6 Socialisation

6.2.6.1 Virtual Residence

In the physical world, domicile and residence are carefully developed and recognised concepts. There is a case to be made for developing and establishing the notion of 'virtual residence' as an extension of the physical residence. It should contribute to a better perception and consideration of ones' personal digital territory and could help to tackle the blurring boundaries of what is public and private in the online world.

Also people are becoming more nomads, moving and travelling, changing jobs, etc. More and more personal information is being disclosed in the virtual world but there is no control of the citizen about what remains accessible and to whom and what disappears. The challenge is to enable ways of dealing with the stability of the past and the discontinuity of the present.

Within a virtual residence, everybody would have access anytime and anywhere to files or digitised documents, photos, films created along his/her life. This is the con-

cept of lifetime virtual boxes of souvenirs and memories, at different levels (personal, family or community) and with differentiated access rights. The family boxes may be passed to the next generations as a legacy.

The technological requirements are important:

- Efficient personalised access to very large repositories, selection & filter of large amount of information (Advanced Knowledge Management, Advanced Data-warehousing);
- This important amount of multimedia material should be accessible anywhere and anytime through any kind of natural-language queries (Cognitive vision, Fuzzy matching, Speech recognition, Learning & adaptive systems);
- The trust and confidence technologies are of utmost importance (Privacy, anonymity protection, Identity Management Systems).

There exist some similarities with “Access to cultural heritage”. Also in-depth socio-economic research is needed to precise the needs, the concepts, and the feasibilities (social, economic, legal, technological).

6.2.6.2 Enhanced Transfer of Knowledge

The issue is to improve communication and understanding between people with new information-sharing, knowledge-transmission and content-exchange practises. Communicating between people is actually based on two successive and relatively inefficient and incomplete translations from the tacit knowledge (what the speaker has in his brain) to the formal knowledge (the spoken or written language) and to the tacit knowledge (what is read or understood and remembered by the interlocutor).

Written documents are in particular often inadequate for synthesising and communicating knowledge within a context of information-overload and an environment dominated by strong multimedia signals and pollution (dynamic images and sounds). People in general and executives in particular have less time and attention to concentrate on written documents. Communication technologies are already steadily shifting from text-centric to broad, sensory-based systems (vision, sound but also tactile and feedback forces) that engage participants in multiple ways.

Ambient Intelligence may constitute part of the answer to facilitate new modes of experiencing and change the way people communicate information, knowledge, ideas, concepts, sensations, feelings and experience through new communication tools.

Breakthroughs could come through new interfaces (multi-sensoriality, multi-modality, multi-lingualism, virtual & augmented reality, telepresence, breakthroughs in input/output such as direct brain/machine or brain/brain interfaces) and displays Technologies (wearable devices, HMD & microdisplays, 3D displays).

As previously, in-depth socio-economic research is needed to precise the needs, the concepts, and the feasibilities (social, economic, legal, technical).

6.2.6.3 New Forms of Socialisation

Only half a century ago, people were meeting within close and pre-determined circles: neighbours, colleagues, clubs, etc. Now, as people start travel and move more, and as family structures are becoming less rigid, new ways of socialising become more and more needed. Even with the recent proliferation of communication tools, the feeling of loneliness is always more widespread in cities, suburbs and even villages in the countryside and the number of single people and single-parent families is steadily increasing.

The paradox is that the crowds who surround us every day constitute a huge waste of social capital. City-dwellers pass everyday within a few meters of people who could give them a ride home, buy an item they are trying to sell, or consider them as potential friends or partners.

The issue is therefore to enrich communication and community life through humanised technology, interactive environments in which people and autonomous systems can get in touch, establish a relation and co-operate in real time.

The vision is that the AmI technologies could change the paradigm of socialisation by putting seamlessly and unobtrusively people in contact on the basis of comparable permanent patterns of interest or specific request. Dynamic networking makes it possible to tap those resources through a momentary alliance among transient interest groups, like people commuting to a certain district, needing a taxi to go to the airport, or sharing similar health concerns. Ad-hoc wireless social contacts or communities between like-minded or shared-interest strangers could therefore emerged spontaneously following negotiation of their respective avatars.

Important developments in Communication & Networking are required (3G+ mobile systems, Fixed/mobile integration, WLAN & broadband networks).

Breakthroughs could come through new interfaces (multi-sensoriality, multi-modality, multi-lingualism, virtual & augmented reality, telepresence, breakthroughs in input/output) and displays Technologies (wearable devices, HMD & microdisplays, 3D displays).

The challenges in terms of trust, confidence and security are enormous (privacy, anonymity protection, Identity Management Systems).

6.2.6.4 Remote Socialisation and Family Life

More and more family are leaving in different countries or even continents. Separations for professional reasons are becoming more frequent and longer. The issue is therefore to allow people to spend time together even if, because of the constraints of modern life or for other reasons, they are in geographically dispersed locations. Interface and displays will be the key enabling technologies. Telepresence, if and when's feasible, would be a major breakthrough.

6.2.6.5 Security and Safety

The issue is to increase the security, or at least the feeling of being secure, by tracking displacements, warning of insecure places and emergency calls. The "Personal Security Assistant" would keep track of the displacements through a GPS-like system and warns the user, and his/her parents if s/he is minor, that s/he is approaching places recorded as being dangerous. In case of an aggression, accident, health problem, the Assistant would automatically call the appropriate help (police, emergency services, parents...).

This function may have commercial success considering the increasing feeling of insecurity. It fits with the tendency of the US and Europe to create well-protected ghettos for the most well-off and to accept implicitly the drift of many suburbs into insecurity.

The "Security Assistant" should not require major technological breakthroughs. The requirements would principally be in terms of network and communication technologies and in terms of wearability (as the Sport & Fitness Assistant).

7 Conclusions

A systematic methodology to investigate the 3D matrix (key functions, key technologies, time) was used to build issue-driven technology and function roadmaps for Ambient Intelligence in Everyday Life.

The identification of the functions, technologies and the timelines has been derived from a careful and iterative process of analysis and synthesis of previous works and from brainstorming. It has been possible to highlight some applications of Aml technologies in terms of useful, accessible and trustworthy innovative functions. These functions are effectively the starting point and leading dimension of our roadmapping methodology, before key technologies and time. This is probably one of the main specificities and added values of our output compared to the existing corporate and industry roadmaps, our “function-oriented” approach seems to be closer to the user.

The question *left* is whether this methodology is relevant and efficient for the study of the interrelationship between the technical and the human (economic, social, societal and demographic) dimensions of Ambient Intelligence. This methodology does not integrate the non-technical dimensions as such, but only through their influences on the functions and technologies. Future challenges would be to take this approach a step further by assessing the potential of the elaborated functions on the basis of user and acceptance criteria such as:

- Money. At what cost the functions can be delivered to include as many people as possible? What percentage of peoples' budget would need to be spent on them?
- Time. Is this new function going to save or cost time?
- Skills. What is the education level required to use this new function?
- User groups. What are the user groups targeted by the functions (youngsters, communities, ...)?

Assuming that the functions are well-designed, well-bordered and firmly grounded on realistic assumptions, it should be possible to derive crude estimations of their inclusive potential, for instance on how many people will have access to specific functions. One drawback of the methodology is that such precisely defined functions would certainly be less innovative and futuristic and probably more short-term improvements of what already exists. Another drawback is the natural tendency to put more emphasis on the areas for which quantitative elements or, in this specific case, clear and undisputable relations are available, to the detriment of areas for which they are not.

Scanning and integrating these qualitative factors within a systematic roadmapping process is theoretically and practically difficult. The “human dimensions” have

rather to be addressed with qualitative and case-by-case studies complementing the identification and characterisation of the key functions.

On the other hand, research on use and acceptance demonstrates that people do not accept and use every innovative function that is technologically made possible and supplied (Punie 2003). In the past, there have been many market failures (e.g. videotext, Video on Demand, WAP) and unforeseen successes (Short Message Services - SMS).

It is therefore difficult to foresee which applications in the future Ambient Intelligence environments will provide the trigger for reaching a critical mass of users. Moreover, people use new technologies in ways that are very different from their intended uses by suppliers (e.g. the Internet, SMS). There is no typical, uniform user and use but rather a diversity of users and uses. Suppliers generally have difficulties in understanding the user market in a qualitative way.

Successful innovation is the result of a specific socio-economic and technological constellation, i.e. the right product, on the right market, at the right time and in the right combination where specific requirements in terms of user needs, user-friendliness, price, attractive supply, standards, interoperability, and so are met. If they are not, the commercialisation will certainly fail. However, failed attempts may ultimately emerge as successful, perhaps in new guises, when the right conditions are in place (Miles ea. 2002).

As a conclusion we can argue that the function-oriented approach we have developed for roadmapping provides fruitful insights about useful and accessible services and reflects some of these “human dimensions”. However, future exercises of scenario and trend building could usefully complement the roadmapping phase.

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Annex A: Broad Technology Areas and Key Technologies

<p>Communication & Networking</p> <ul style="list-style-type: none"> • WAN & LAN broadband networks • 3G+ /4G mobile systems • Fixed/mobile integration (Mobile IP, IPV6) • Widely available GPS-like systems • Optical routing and processing • P2P networks • Body Networks • Adaptive flexible networks • Location technologies • Advanced services and applications provisioning technologies 	<p>Software</p> <ul style="list-style-type: none"> • Large-scale distributed systems • GRID Computing • Workflow management • Embedded systems • Light weight OS's • New and open standards • Advanced Software Engineering (Robust development tools and platforms) • Plug and play (seamless and dynamic self-testing, -configuring & -reconfiguring software) • Artificial Agent • Self -organising & -repairing software • Personalization
<p>Micro Systems & Electronics (incl. Storage)</p> <ul style="list-style-type: none"> • Networked sensors & actuators • Bodily sensors • Nano-sensors • Nano-systems • Hybrid nano/macro • Hybrid bio/electro • New materials 	<p>User Interfaces</p> <ul style="list-style-type: none"> • Multi-lingualism • Multi-sensoriality (sight, hearing, touch) • Multi-modality (speech, touch, expressions, gestures, voice mark-ups) • Virtual and augmented reality, visualisation • Breakthroughs in input/output (brain-brain and brain-machine interfaces)

<p>Displays</p> <ul style="list-style-type: none"> • Wearable, advanced portable displays (flat, foldable and rollable) • Head Mounted Displays (HMD) & Microdisplays • 3D displays 	<p>Knowledge Management</p> <ul style="list-style-type: none"> • Semantic web (Meta-data) • Knowledge GRIDS • Advanced Knowledge Management • Advanced data warehousing (object and multimedia databases), Knowledge Discovery in Databases (KDD advanced searching & data mining), OLAP (on-line analytical processing) • Networked knowledge sharing • Ontologies • Converging media (integrating information from various sources/ systems)
<p>Artificial Intelligence</p> <ul style="list-style-type: none"> • Cognitive vision (pattern recognition, content-based image indexing & retrieving) • Speech recognition • Learning & adaptive systems • Advanced profiling • Context-sensitive & affective computing • Artificial Intelligent Agent • Artificial tasting and smelling 	<p>Power sources</p> <ul style="list-style-type: none"> • Lower power consumption • Advanced battery and fuel cells • Use of ambient power & self-generating power • Wireless Power Transmission
<p>Trust and Security</p> <ul style="list-style-type: none"> • Privacy, anonymity protection • Identity Management Systems • Digital Rights Management • Secure transactions & payments (encryption, biometrics, digital signature, micro-payments) • Dependability (reliability, maintainability, maintainability support), fault tolerance 	

Annex B: Application Areas, Key Functions and Key Technologies

B.1 Housing

Application sub-areas	Key Functions	Communication & Networking	Software technologies	Micro-systems & Electronics	Interfaces & Displays	Knowledge technologies	Artificial intelligence	Trust & Security	Power sources
Home automation	Environment control (including but not limiting to hpac, doors, lighting, etc)	Residential networks, Short-range wireless and powerline communication	Embedded system, Plug & Play, light weight OS	Sensor and actuator technology	Large displays, user friendly design for all, multi-modal UI, voice UI, Affective Computing		Anticipation of resident's profile and preferences, unobtrusive actuators in home automation	Authentication, privacy protection, dependability	partly low-power electronics
	Security	Residential networks, short-range wireless and powerline communication	Embedded systems, light weight OS's, new and open standards	Bodily sensors and actuators, hybrid bio/electro systems, bio-identification (fingerprint, iris-scan, etc)	(Personal) Wearable devices, multi-sensor & multi-modal interfaces	Converging media, advanced data warehousing	Speech-recognition, Intelligent agents, context-sensitive & adaptive systems, advanced profiling, Pattern recognition	Identification and authentication, dependability	Low-power (wearable) devices

Application sub-areas	Key Functions	Communication & Networking	Software technologies	Micro-systems & Electronics	Interfaces & Displays	Knowledge technologies	Artificial Intelligence	Trust & Security	Power sources
Communication & socialisation	Person to person communication	2G- 3G+ technologies,	Intelligent/ Artificial agents	Bodily sensors	Multi-lingual and -model interfaces, Virtual and augmented reality	Networked knowledge sharing	Avatars	Privacy protection, anonymity, Secure transactions	Low power consumption
	Person to community communication	2,5G-3G+ technologies, Wireless connections, internet technologies	Intelligent agents, virtual communities,	bodily sensors,	Multi-lingual and Multi-modal interfaces, Virtual and augmented reality	Networked knowledge sharing, Semantic Web	Avatars	Privacy protection, anonymity, Secure transactions	
	Tele-presence	2,5G-3G+ technologies, broadband connections, web-cam, video-conferencing	Plug and play, Artificial agents, new and open standards, location technologies	Bodily sensors, networked sensors and actuators	Multi-lingual and multimodal interfaces, virtual and augmented reality		Avatars	privacy protection, secure transactions	Low power (wearable) devices
Rest & Relaxation, Entertainment	Entertainment	3G+ mobile systems, Fixed/ mobile integration, wireless and broadband networks	Embedded systems, large scale distributed systems	Networked sensors & actuators, Faster devices	Human factors emphasised in design, Multi-sensory, multi-lingual, multi-lingual, virtual & augmented reality, wearable devices, displays on any surfaces Head-up-displays & Micro-displays	Semantic web	Fuzzy matching, Cognitive vision, Learning systems, Context-sensitivity & affective computing		
	Rest & Relaxation	short-range wireless and powerline communication, networked home appliances	embedded systems, plug and Play, light weight OS, new and open standards	Networked sensors & actuators, New (smart) materials, bio-sensors	Multi-sensory and multi-modal interfaces, Voice interface,	Semantic web	advanced profiling, context sensitivity, affective computing,	identification and authentication	low-power wearable devices, ultra-low-power implants
Application sub-areas	Key Functions	Communication & Networking	Software technologies	Micro-systems & Electronics	Interfaces & Displays	Knowledge technologies	Artificial Intelligence	Trust & Security	Power sources

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Rest & Relaxation, Entertainment (continued)	Refreshing/ hygiene	short-range wireless and powerline communication, networked home appliances	light-weight OS, embedded systems, open standards	networked sensors & actuators, smart materials, biosensors	Displays in other surfaces (e.g. mirror), voice interface	advanced profiling, context sensitivity, affective computing,	identification and authentication	low-power (wearable) devices, ultra-low-power implants
Work & Learning	Household work	short range-wireless communication, ad-hoc-networking of everyday objects	new & open standards, plug and play,	networked sensors & actuators, smart-materials	Voice interface, common displays	knowledge management and sharing	identification and authentication	low-power devices
	maintenance work	short-range wireless communication	embedded systems	networked sensors & actuators, smart-materials, biosensors	Voice interfaces	networked knowledge sharing	context awareness, control and guiding systems of household robots	
	Hoffice work	3G+ mobile systems, Fixed/mobile integration, wireless and broadband networks, video-conferencing	tele-presence, unobtrusive devices (smaller ICT-technology)		Displays in other surfaces, multilingual interfaces,	semantic web, networked knowledge sharing	identification and authentication	

B.2 Mobility and Transport

	Key Functions	Communication & Networking	Software technologies	Micro-systems & Electronics	Interfaces & Displays	Knowledge technologies	Artificial Intelligence	Trust & Security	Power sources	Acceptance factors
Traffic Management	Traffic Monitoring	3G+ Mobile Networks Scalability	large scale distributed system real time	networked sensors			Pattern Recognition Self diagnosis	privacy (data from individual travelers)		trust of users (collection of individual movements) uncontrolled exchange of information large investment in infrastructure
	Dynamic Routing	3G+ Mobile Networks Scalability	large scale distributed system real time fault tolerance	low power, e-ink display	Multi-modality (speech technologies) Multi-lingualism		self diagnosis	privacy (data from individual travelers) dependability		opposing goal (traffic optimisation vs. Environmental protection).
	Ticketing and Control	(3G+ Mobile Networks) (Scalability)	fault tolerance real time Plug and Play	smaller cheaper low power	Wearable devices			secure transactions micro payment liability privacy identification of person	low power consumption	mistrust of users (recording of movement; charging without direct feedback)

	Key Functions	Communication & Networking	Software technologies	Micro-systems & Electronics	Interfaces & Displays	Knowledge technologies	Artificial Intelligence	Trust & Security	Power sources	Acceptance factors
Navigation	Real-Time Traffic Information	3G+ Mobile Networks Scalability	real time, dynamic reconfiguration Embedded Systems	networked sensors smaller cheaper low power e-ink displays	Multi-lingualism augmented reality	Tagging/ Meta Data	Context Awareness	dependability micro payment	low power consumption	large investment in infrastructure unwillingness of public to pay for traffic information
	Travel Assistance	3G+ Mobile Networks P2P networking GPS (like) Systems	real time, dynamic reconfiguration Embedded Systems Plug and Play	memories smaller faster cheaper low power e-ink displays	Multi-lingualism augmented reality Wearable devices ?	Tagging/ Meta Data	Context Awareness	dependability micro payment	low power consumption	undesirability of inter modal travelling among important suppliers
	Individual Navigation	3G+ Mobile Networks GPS (like) Systems car networking	real time, dynamic reconfiguration Embedded Systems Plug and Play ?	memories, smaller, faster cheaper low power e-ink displays	augmented reality Multi-modality (speech technologies) Multi-lingualism Wearable devices (not in car)		Context Awareness Self Diagnosis	dependability micro payment	low power consumption	high initial cost declining advantage for individual when dissemination increases
Safety	Driver Surveillance		real time Embedded Systems	bodily sensors & processors, faster smaller cheaper	bodily interface adaptiveness (borderline between manual and automatic control) Multi-modality Wearable devices (not in car ?)		Pattern Recognition Context Awareness Self Diagnosis	dependability identification of person		reluctance to use an automatic control system; reliability crucial (threshold for switch off very low); privacy of information (reporting to police, insurances)

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Key Functions	Communication & Networking	Software technologies	Micro-systems & Electronics	Interfaces & Displays	Knowledge technologies	Artificial Intelligence	Trust & Security	Power sources	Acceptance factors
Vehicle and Environment Surveillance Safety (continued)	P2P networking	fault tolerance real time, dynamic reconfiguration Embedded Systems	faster processors (cheap, small)	adaptiveness (borderline between manual and automatic control) Multimodal interfaces		Pattern Recognition Self Diagnosis	dependability	appropriate for car battery	reluctance to use an automatic control system; reliability crucial (threshold for switch off very low);
Information	3G+ Mobile Networks GPS (like) Systems	fault tolerance near real time; dynamic reconfiguration Embedded Systems	memories, cheap fast	Multi-modality, augmented reality; multi-lingualism	Tagging/ Meta Data Semantic Web ?		secure transactions micro payment		appropriate human-machine interface (not diverting attention, no manual control) dense infrastructure (quality of service);
Entertainment	3G+ Mobile Networks Scalability other broadband networking technologies	dynamic reconfiguration Plug and Play ?	faster processors, small memories	Advanced flexible displays			micro payment	appropriate for car battery	dense infrastructure (quality of service); low cost
Mobile Information and Entertainment	Interoperability	open standards	low power (not for single function but in the sum!)	visibility of displays (high resolution; high contrast)				always on & energy consuming displays	existence of open standards and interoperability
relevant for all sub-fields									

B.3 Shopping and Commerce

	Key Functions	Communication & Networking	Software	Microsystems & Electronics (Storage)	User Interfaces	Displays	Knowledge Management	Artificial Intelligence	Trust & Security	Power sources	Social categories
E-business & E-commerce	Catalogue services, Shopping cart	WAN & LAN broadband networks; Optical routing and processing	Workflow management		Multilingualism; multi sensoriality	3D displays	Semantic web (Meta-data)				everybody
	Order processing, Configurators	WAN & LAN broadband networks; Optical routing and processing	Workflow management		multi sensoriality	3D displays	Semantic web, ontologies				everybody
	Marketing, Personalization	Location technologies	Personalization		Multilingualism; multi modality		Advanced Knowledge Management; Data warehousing; Knowledge discovery in databases	Advanced profiling; context-sensitive	Privacy, anonymity protection		executives
	Security and Privacy	IPv6							Privacy, anonymity protection; identity management system, DRM, Secure transactions		everybody

	Key Functions	Communication & Networking	Software	Microsystems & Electronics (Storage)	User Interfaces	Displays	Knowledge Management	Artificial Intelligence	Trust & Security	Power sources	Social categories
Retailing	Retailing	Fixed/ Mobile integration	Embedded system; Light weight OS's	Networked sensors & actuators					Identity management; secure transactions; reliability	Wireless power transmission	shoppers; retailers
	Secure storage boxes	Fixed/ mobile integration (Mobile IP, IPv6)	Embedded system; Light weight OS's	Networked sensors & actuators					Identity Management, reliability	Lower power consumption	commuters, singles, people living in rural areas
Logistics	Collection and delivery points	Fixed/ Mobile integration	Embedded system; Light weight OS's	Networked sensors & actuators					Identity management; secure transactions; reliability		commuters, singles, people living in rural areas
	Data collection for operational efficiency	Fixed/ Mobile integration; Location	Workflow management; personalization				Data warehousing; Knowledge management			Dependability; anonymity	everybody
Mobile commerce	Mobility	3G+ / 4G mobile systems; Fixed/ Mobile integration, Ipv6; Location technologies; adaptive flexible network		Bodily sensors	Multilingualism; multimodality, multisensoriality	Wearable, advanced portable displays, HMD& Microdisplays		Speech recognition; context sensitive	Privacy, anonymity protection; identity management system, DRM, Secure transactions	Lower power consumption; advanced battery fuel cells	mobile workers, commuters
	Location	Location technologies; 3G+ 4G mobile system; widely available GPS-like system		Networked sensors & actuators			Advanced Knowledge Management;	Privacy, anonymity			everybody
	Personalization		Personalization	Bodily sensors	Multimodality; multilingualism		Advanced knowledge management; data warehousing	Advanced profiling; context-sensitive	Privacy		foreigners, immigrants

Key Functions	Communication & Networking	Software	Microsystems & Electronics (Storage)	User Interfaces	Displays	Knowledge Management	Artificial Intelligence	Trust & Security	Power sources	Social categories
Voice technologies				Multi-lingualism			Speech recognition; context sensitive	biometrics		disabled
DAM & DRM	P2P network; WLAN & LAN broadband networks							DRM; secure transactions		publishing houses, record and movie companies

B.4 Education and Learning

Key Functions	Social categories	Communication & Networking	Software	Micro systems & Electronics (Storage)	User Interfaces	Displays	Knowledge management	Artificial Intelligence	Trust & Security	Power sources
School/University: Face to Face (F2F)	Educators, Learners	tele-video/audio-conferencing /web seminar; local and external network; satellite, LAN, WAN, network communication technology (see glossary); blended learning technologies	Web based technologies; shared DBMS (data based management system)	nanotechnologies, digital ink	Seamless technology, calm technology	electric paper	Document management; WBKMS (web based knowledge management system)		property, right protection, dependability (reliability, maintainability); cybersecurity	lower power consumption

Key Functions	Social categories	Communication & Networking	Software	Micro systems & Electronics (Storage)	User Interfaces	Displays	Knowledge management	Artificial Intelligence	Trust & Security	Power sources
School/University; Distance learning/ E_learning	Remote worker learners, educators, mentors, virtual community, learning circles; disabled people	tele-video/audio- conferencing /web seminar and desktop confer- ence; local and external network: satellite, LAN, WAN; synchro- nous/ asynchro- nous technology; Collaboration technology; whiteboard tech- nology; interac- tive notebook technology; Push pull technology; network and communication technology (see glossary); client server technol- ogy; CoD, AoD, VoD technology; screen reader technology	learning games; LCMS (Learning content manage- ment system); authoring tools, XML, WML, XSL language; stan- dards	Bluetooth; nanotechnolo- gies, digital ink	Seamless tech- nology; query system technol- ogy; multimedia interface (sound, video, animation, graphic and photographic); User's profile / customisation technology; web archiving; calm technology	interactive/ active screen (roll- overs), electric paper	, Document man- agement; WBKMS (web based knowledge management system); Multi- media information management; Learning content management system; Expert system	simulation; multi- lingual dialogue mode; virtual interactive reality, virtual classroom; Semantic web; Ontologies; Entity recognition; In- formation extrac- tion; Image re- trieval; learning strategies	property, right protection, de- pendability (reli- ability, maintain- ability); cyberse- curity	lower power consumption

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Key Functions	Social categories	Communication & Networking	Software	Micro systems & Electronics (Storage)	User Interfaces	Displays	Knowledge management	Artificial Intelligence	Trust & Security	Power sources
School/University: evaluation/ accreditation	Educators, worker/remote learners, mentors, disabled people	tele-video-audio-conferencing; local and external network: satellite, LAN, WAN; network and communication technologies(see glossary); screen reader technology	questionnaire management system; knowledge advisor/assessment	digital ink	Seamless technology; query system technology; multimedia interface (sound, video, animation, graphic and photographic); User's profile / customisation technology;	interactive/active screen (roll-overs)	knowledge advisor/assessment	Test engine; control and diagnostic system technology	secure transaction; privacy; dependability (reliability, maintainability); cyber security	
School/University: digital Library	everybody	local and external network: satellite, LAN, WAN; network and communication technologies (see glossary); CoD technology	XML, WML, XSL language; standards	nanotechnologies, magnetoresistance technology (PCMCIA), electronic book	Seamless technology; query system technology; multimedia interface (sound, video, animation, graphic and photographic); User's profile technology; Multimedia information management; web archiving,	3D display, electric paper	Document management; Multimedia information management; Access, searching and browsing technology	multilingual dialogue mode; virtual interactive reality; Semantic web; Ontologies; Entity recognition; Information extraction; summarisation technology	property, right protection, dependability (reliability, maintainability); cyber security	lower power consumption

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Key Functions	Social categories	Communication & Networking	Software	Micro systems & Electronics (Storage)	User Interfaces	Displays	Knowledge management	Artificial Intelligence	Trust & Security	Power sources
School/University: digital Museum	everybody	local and external network: satellite, LAN, WAN; network and communication technologies (see glossary), CoD, AoD, VoD technology;	XML, WML, XSL language; standards	nanotechnologies	Seamless technology; query system technology; multimedia interface (sound, video, animation, graphic and photographic); User interface technology; Multimedia information management;	3D display	Multimedia information management;	multilingual dialogue mode; virtual interactive reality; Image retrieval	property, right protection, dependability (reliability, maintainability); cyber security	lower power consumption
Work/Training: Face to Face (F2F)	Trainers, Trainees	tele-video/audio-conferencing / web seminar; local and external network: satellite, LAN, WAN, network communication technology (see glossary); blended learning technologies	Web based technologies; shared DBMS (data based management system)	nanotechnologies	Seamless technology, calm technology	electric paper	Document management; WBKMS (web based knowledge management system)		property, right protection, dependability (reliability, maintainability); cyber security	lower power consumption

Key Functions	Social categories	Communication & Networking	Software	Micro systems & Electronics (Storage)	User Interfaces	Displays	Knowledge management	Artificial Intelligence	Trust & Security	Power sources
Work/Training: E_training	Trainers, Trainees	tele-video/audio-conferencing / web seminar and desktop conference; local and external network: satellite, LAN, WAN; synchronous/asynchronous technology; Collaboration technology; whiteboard technology; interactive notebook technology; Push pull technology; network and communication technology (see glossary); client server technology; CoD, AoD, VoD technology; screen reader technology	role games; LCMS (Learning content management system); authoring tools, XML, WML, XSL language; standards	Bluetooth; nanotechnologies, digital ink	Seamless technology; query system technology; multimedia interface (sound, video, animation, graphic and photographic); User's profile / customisation technology; web archiving;	interactive/ active screen (rollers), electric paper	Document management; WBKMS (web based knowledge management system; ; Multi-media information management; Learning content management system; Expert system	simulation; multilingual dialogue mode; virtual interactive reality, virtual classroom; Semantic web; Ontologies; Entity recognition; Information extraction; Image retrieval; learning strategies	property, right protection, dependability (reliability, maintainability); cyber security	lower power consumption

Key Functions	Social categories	Communication & Networking	Software	Micro systems & Electronics (Storage)	User Interfaces	Displays	Knowledge management	Artificial Intelligence	Trust & Security	Power sources
Work/Training: Evaluation/ certification	Trainers, trainees and remote trainees, mentors, disabled trainees	tele-video/audio-conferencing; local and external network: satellite, LAN, WAN; network and communication technologies (see glossary); screen reader technology	questionnaire management system; knowledge advisor/assessment	digital ink	Seamless technology; query system technology; multimedia interface (sound, video, animation, graphic and photographic); User's profile / customisation technology;	interactive/active screen (roll-overs)	knowledge advisor/assessment	Test engine; control and diagnostic system technology, Learning agent technologies	secure transaction; privacy; dependability (reliability, maintainability); cyber security	
Learning centres/ individual learning: Face to Face (F2F)	Learners, Learning facilitator, Companies, Social organisation,	tele-video/audio-conferencing / web seminar; local and external network: satellite, LAN, WAN, network communication technology (see glossary); blended learning technologies	Web based technologies; shared DBMS (data based management system)	nanotechnologies, digital ink	Seamless technology, calm technology	electric paper	Document management; WBKMS (web based knowledge management system)		property, right protection, dependability (reliability, maintainability); cyber security	lower power consumption

Key Functions	Social categories	Communication & Networking	Software	Micro systems & Electronics (Storage)	User Interfaces	Displays	Knowledge management	Artificial Intelligence	Trust & Security	Power sources
Learning centres/ individual learning: E_learning	remote/worker learners, mentors, virtual community, learning circles; disabled people, Companies, Social organisation,	tele-video/audio- conferencing / web seminar and desktop confer- ence; local and external network: satellite, LAN, WAN; synchro- nous/ asynchro- nous technology; Collaboration technology; whiteboard tech- nology; interac- tive notebook technology; Push pull technology; network and communication technology (see glossary); client server technol- ogy; CoD, AoD, VoD technology; screen reader technology	learning games; LCMS (Learning content manage- ment system); authoring tools, XML, WML, XSL language; stan- dards	Bluetooth; nanotechnolo- gies, digital ink	Seamless tech- nology; query system technol- ogy; multimedia interface (sound, video, animation, graphic and photographic); User's profile / customisation technology; web archiving; calm technology	interactive/ active screen (roll- overs), electric paper	Document man- agement; WBKMS (web based knowledge management system; Multime- dia information management; Learning content management system; Expert system	simulation; multi- lingual dialogue mode; virtual interactive reality; virtual classroom; Semantic web; Ontologies; Entity recognition; In- formation extrac- tion; Image re- trieval; learning strategies	property, right protection, de- pendability (reli- ability, maintain- ability); cyber security	lower power consumption

Key Functions	Social categories	Communication & Networking	Software	Micro systems & Electronics (Storage)	User Interfaces	Displays	Knowledge management	Artificial Intelligence	Trust & Security	Power sources
Learning centres/ individual learning: digital Library	everybody	local and external network: satellite, LAN, WAN; network and communication technologies (see glossary), CoD technology;	XML, WML, XSL language; standards	nanotechnologies, magnetoresistance technology (PCMCIA), electronic book	Seamless technology; query system technology; multimedia interface (sound, video, animation, graphic and photographic); User's profile technology; Multimedia information management; web archiving;	3D display, electric paper	Document management; Multimedia information management; Access, searching and browsing technology	multilingual dialogue mode; virtual interactive reality; Semantic web; Ontologies; Entity recognition; Information extraction; summarisation technology	property, right protection, dependability (reliability, maintainability); cyber security	lower power consumption
Learning centres/ individual learning: digital Museum	everybody	local and external network: satellite, LAN, WAN; network and communication technologies (see glossary); CoD, AoD, VoD technology	XML, WML, XSL language; standards	nanotechnologies	Seamless technology; query system technology; multimedia interface (sound, video, animation, graphic and photographic); User interface technology; Multimedia information management;	3D display	Multimedia information management;	multilingual dialogue mode; virtual interactive reality; image retrieval	property, right protection, dependability (reliability, maintainability); cyber security	lower power consumption

B.5 Culture, Leisure and Entertainment

	Key Functions	Communication & Networking	Software	Microsystems & Electronics (Storage)	User Interfaces	Displays	Knowledge Management	Artificial Intelligence	Trust & Security	Power sources
Avatar	Personal Information Assistants	3G+ mobile systems Fixed/mobile integration WAN & broadband networks Widely available GPS-like systems	Intelligent Agents Embedded systems Light weight OS's	Bodily sensors	Multi-lingualism	Wearable devices Advanced portable displays	Semantic web Networked knowledge sharing Converging media Knowledge Discovery in Databases Distributed databases	Learning & adaptive systems Advanced profiling Context-sensitive & affective computing Intelligent Agent	Privacy, anonymity protection Identity Management Systems Digital Rights Management Secure transactions & micro-payments Dependability (reliability, maintainability)	Lower power consumption
Cultural Heritage	Preservation of cultural heritage	local and external network: satellite, LAN, WAN, civic network	Large-scale distributed systems Embedded systems New and open standards				Semantic web		Digital Rights Management	
	Organisation of cultural heritage	WLAN & broadband networks	Large-scale distributed systems Embedded systems XML, WML, XSL languages		Multi-lingualism		Semantic web, ontologies Advanced Knowledge Management Advanced Data warehousing OLAP, advanced query system	Fuzzy matching Speech recognition	Digital Rights Management Dependability (reliability, maintainability)	

	Key Functions	Communication & Networking	Software	Microsystems & Electronics (Storage)	User Interfaces	Displays	Knowledge Management	Artificial Intelligence	Trust & Security	Power sources
Cultural heritage (continued)	Access to and retrieval of cultural heritage Digital Libraries & Multimedia Rentals Life long learning/training	3G+ mobile systems Fixed/mobile integration LAN, WAN & broadband networks	Large-scale distributed systems Embedded systems XML, WML, XSL languages; open standards	Networked sensors & actuators Magneto-resistance technology (PCMCIA), electronic book	Multi-lingualism Multi-sensoriality Multi-modality & multimedia interface (sound, video, animation, graphic and photographic)		Semantic web, ontologies Advanced Knowledge Management Advanced Data warehousing Access, searching and browsing technology CoD, AoD, VoD technology Converging media	Cognitive vision Fuzzy matching Speech recognition Entity recognition; information extraction Context-sensitive search & retrieval Advanced profiling	Digital Rights Management Dependability (reliability, maintainability)	
	Intelligent heritage and cultural tourism (historical sites/museums/exhibitions)	LAN, WAN & broadband networks 3G+ mobile systems	Large-scale distributed systems Embedded systems XML, WML, XSL language; open standards	Networked sensors & actuators	Multi-sensoriality Multi-modality, multimedia interface (sound, video, animation, graphic and photographic) Virtual & augmented reality	3D displays	Semantic web, ontologies Advanced Knowledge Management Advanced Data warehousing CoD, AoD, VoD technology Converging media Access, searching and browsing technology	Advanced profiling Cognitive vision	Digital Rights Management Dependability (reliability, maintainability)	Lower power consumption

	Key Functions	Communication & Networking	Software	Microsystems & Electronics (Storage)	User Interfaces	Displays	Knowledge Management	Artificial Intelligence	Trust & Security	Power sources
Cultural Participation	"Out-of-house" cultural participation and recreation (film, theatre, dance, music, amusement parks, sport events, manifestations)	3G+ mobile systems WLAN & broadband networks	Large-scale distributed systems Embedded systems	Networked sensors & actuators	Multi-sensoriality Multi-modality Multi-lingualism Virtual & augmented reality Telepresence		Semantic web Advanced Knowledge Management Advanced Data warehousing Converging media	Cognitive vision Content-based image indexing and retrieving Speech recognition Learning & adaptive systems Context-sensitive & affective computing	Privacy, anonymity protection Digital Rights Management	Lower power consumption
	Creation & Art	3G+ mobile systems WLAN & broadband & ad-hoc networks	Embedded systems Intelligent Agents Large-scale distributed systems	Networked sensors & actuators Bodily sensors	Multi-sensoriality Multi-modality Multi-lingualism Virtual & augmented reality Telepresence Breakthroughs in input/output	3D displays	Semantic web Advanced Data warehousing Networked knowledge sharing Converging media	Learning systems Advanced profiling Context-sensitive & affective computing	Privacy, anonymity protection Digital Rights Management	
Media	Reading (newspaper, magazine, book)		Embedded systems Light weight OS's Open standards	WAN	Multi-lingualism	Advanced portable displays	Advanced Knowledge Management Advanced data warehousing		Digital Rights Management Micro-payments	Lower power consumption
	News & Information	3G+ mobile systems Fixed/mobile integration	WAN Embedded systems Light weight OS's		Multi-lingualism	Advanced portable displays		Advanced profiling	Digital Rights Management Micro-payments	

	Key Functions	Communication & Networking	Software	Microsystems & Electronics (Storage)	User Interfaces	Displays	Knowledge Management	Artificial Intelligence	Trust & Security	Power sources
Entertainment	Multimedia entertainment (listening, watching, interacting) Playing & Gaming	Broadband networks Optical routing and processing	Embedded systems Light weight OSs		Multi-lingualism Virtual & augmented reality Telepresence	3D displays	Semantic web Advanced Knowledge Management Advanced Data warehousing Converging media	Fuzzy matching Speech recognition	Privacy, anonymity protection Digital Rights Management Secure transactions & payments	
		3G+ mobile systems Fixed/mobile integration WLAN & broadband networks Optical routing and processing	Embedded systems Large-scale distributed systems	Networked sensors & actuators Bodily sensors	Multi-sensoriality Multi-modality Multi-lingualism Virtual & augmented reality Telepresence Breakthroughs in input/output	Wearable, HMD & Microdisplays 3D displays	Semantic web Converging media	Fuzzy matching Cognitive vision Learning systems Context-sensitive & affective computing	Privacy, anonymity protection Digital Rights Management Secure transactions & payments Dependability (reliability, maintainability)	Lower power consumption
Sport & fitness		3G+ mobile systems Wireless Wide Area networks Widely available GPS-like systems	Embedded systems Light weight OSs	Bodily sensors		Wearable devices				

B.6 Health

Application sub-areas	Key Functions	Communication & Networking	Software technologies	Micro-systems & Electronics	Interfaces & Displays	Knowledge technologies	Artificial Intelligence	Trust & Security	Power sources
Prevention	Monitoring	3G+ mobile systems; Wireless BAN; GPS-like systems	Large scale distributed systems; Embedded systems; Lightweight OS's; Plug and play	Networked sensors & actuators; Bodily sensors; Nano-sensors; Nano-systems; Hybrid bio/electro	Multi-sensoriality; Multi-modality; Virtual & augmented reality; Wearable devices; Advanced portable displays; Microdisplays	Semantic web; Advanced data warehousing; Networked knowledge sharing	Learning & adaptive systems & advanced profiling; Context-sensitive & affective computing	Privacy, anonymity, protection; Rights protection, liability; Dependability	Lower power consumption; Use of ambient power & self-generating power
	Consultation	3G+ Mobile systems, Wireless networks; Broadband networks	Intelligent agents; New and open standards		Design based on Human factors; multi-modality	Knowledge management; Networked knowledge sharing; Converging media	Learning & adaptive systems & advanced profiling	Privacy, anonymity, protection	
	Information and Education	3G+ mobile systems Fixed/mobile integration; Broadband networks	Large scale distributed systems; Lightweight OS's; New and open standards; Advanced software engineering		Multi-modality; Multilingualism; Displays on any surface; Wearable devices	Semantic web; Networked knowledge sharing; Converging media; Ontologies; Advanced data warehousing	Fuzzy matching; Learning & adaptive systems & advanced profiling; Context-sensitive & affective computing	Rights protection, liability; Secure transactions & payment	Lower power consumption
	Prediction	3G+ mobile systems; Fixed/mobile integration; Wireless networks	Large scale distributed systems; New and open standards; Intelligent agents	Networked sensors & actuators; hybrid bio/electro; hybrid nano/macro	Multi-sensoriality; Multi-modality; Wearable devices	Advanced data warehousing; Knowledge discovery in databases; Ontologies; Converging media	Learning & adaptive systems & advanced profiling	Privacy, anonymity, protection	Lower power consumption

Application sub-areas	Key Functions	Communication & Networking	Software technologies	Micro-systems & Electronics	Interfaces & Displays	Knowledge technologies	Artificial Intelligence	Trust & Security	Power sources
Cure	Diagnosis	Fixed/mobile integration; Wireless networks; Broadband networks; Optical routing and processing	Embedded systems; Large scale distributed systems; New and open standards	Networked sensors & actuators; nano sensors; hybrid bio/electro	Multi-sensoriality Multi-modality; Virtual & augmented reality; Multi-lingualism; Advanced portable displays	Advanced data warehousing; Knowledge discovery in databases; Ontologies; Converging media	Cognitive vision; Fuzzy matching; Learning & adaptive systems & advanced profiling; Context-sensitive & affective computing	Privacy, anonymity, protection; Rights protection, liability; dependability	Lower power consumption
	Treatment and Surgery	Fixed/mobile integration; Optical routing & processing; Wireless & broadband networks	Large scale distributed systems; Embedded systems; Plug and play; Advanced software engineering; Self-organising and re-pairing software	New materials; Nano sensors; Hybrid pharmaceutical; Hybrid bio/electro; Nano-systems	Design based on human factors; Multi-sensoriality Multi-modality; virtual and augmented reality; head-up displays & micro-displays; Breakthroughs in input/output	Knowledge management; Advanced data warehousing; Knowledge discovery in databases; Ontologies; Networked knowledge sharing; Converging media	Cognitive vision; Speech recognition; Context-sensitive & affective computing	Dependability; Secure transactions & payments; Privacy, anonymity, protection; Rights protection, liability	Lower power consumption; Advanced battery and fuel cells
	Monitoring	3G+ networks; Wireless networks; Widely available GPS-like systems	Large scale distributed systems; Embedded systems; Light weight OS's	Networked sensors & actuators; Bodily sensors; Nano-sensors; Nano-systems; Hybrid bio/electro	Multi-sensoriality; Multi-modality; Wearable devices	Semantic web; Advanced data warehousing; Networked knowledge sharing	Learning & adaptive systems & advanced profiling; Context-sensitive & affective computing	Privacy, anonymity, protection; Secure transactions & payments; Dependability	Lower power consumption; Use of ambient power & self-generating power

Application sub-areas	Key Functions	Communication & Networking	Software technologies	Micro-systems & Electronics	Interfaces & Displays	Knowledge technologies	Artificial Intelligence	Trust & Security	Power sources
Care	Monitoring	3G+ networks; Wireless networks; Widely available GPS-like systems	Large scale distributed systems; Embedded systems; Light weight OS's	Networked sensors & actuators; Bodily sensors; Nano-sensors; Nano-systems; Hybrid bio/electro	Multi-sensoriality Multi-modality Multilingualism Virtual & augmented reality	Semantic web; Advanced data warehousing; Networked knowledge sharing	Learning & adaptive systems & advanced profiling; Context-sensitive & affective computing	Privacy, anonymity, protection; Dependability	Lower power consumption; Use of ambient power & self-generating power
	Attending	3G+ mobile systems; Fixed/mobile integration; Wireless & broadband networks	Embedded systems; Large scale distributed systems; Advanced software engineering; Plug and play; New and open standards	Networked sensors and actuators; Hybrid nano/macro; Hybrid bio/electro	Multi-modality; Design based on human factors; Multi-sensoriality; Wearable devices	Semantic web; Networked knowledge sharing; Converging media	Speech recognition; Learning & adaptive systems & advanced profiling; Context-sensitive & affective computing	Privacy, anonymity, protection; dependability	Lower power consumption
Health management and administration	Commerce	3G+ mobile systems; Fixed/mobile integration; Wireless & broadband networks	Large scale distributed systems; Embedded systems; GRID computing		Design based on human factors; Multi-modality; Multilingualism; Virtual & augmented reality	Semantic web; Advanced data warehousing; Converging media	Learning & adaptive systems & advanced profiling; Context-sensitive & affective computing	Privacy, anonymity, protection; Rights protection, liability; Secure transactions & payments	In case of BAN: Lower power consumption
	Identification and authentication	3G+ networks; Wireless networks; Widely available GPS-like systems	Large scale distributed systems; Embedded systems; Light weight OS's	Networked sensors & actuators; Nano-sensors; Hybrid bio/electro	Multi-sensoriality; Multi-modality; Multilingualism	Semantic web Advanced data warehousing	Learning & adaptive systems & advanced profiling	Privacy, anonymity, protection; Secure transactions & payments	Lower power consumption

Annex C: Experts involved in the Roadmapping Process

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