The Future of Ambient Intelligence in Europe:The Need for More Everyday Life

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Abstract: Ambient Intelligence (AmI) refers to a vision of the future information society where intelligent interfaces enable people and devices to interact with each other and with the environment. Today, most of the technologies needed for the realisation of this vision are next-generation technologies that are not currently on the market, but are being researched by research institutes and corporate laboratories worldwide. In Europe, the IST Advisory Group (ISTAG) and the FP6 IST programme are strong promoters of the AmI vision. This article gives a short overview of AmI, focuses on its role in everyday life and identifies some of the major challenges and bottlenecks facing the concept. The paper argues that, although people are presented as at the core of the vision, AmI would benefit from a more substantial everyday life perspective that confronts users in their everyday lives with future visions and technologies. Some of the key issues raised by such an approach are identified and discussed.
Key words: Research, development policy.

Ambient Intelligence (AmI) refers to a vision of the future information society where intelligent interfaces enable people and devices to interact with each other and with the environment [1]. Technology operates in the background while computing capabilities are everywhere, connected and always available. This intelligent environment is aware of the specific characteristics of human presence and preferences, takes care of needs and is capable of responding intelligently to spoken or gestured indications of desire. It even can engage in intelligent dialogue. AmI is all about 'human centred computing', user-friendliness, user empowerment and the support of human interaction (ISTAG, 2001; HARWIG & SCHUURMANS, 2001).

Many implicit shifts underscore this vision. The first is the one in which computing systems move from mainframe computing (1960-1980) to

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personal computing (1980-1990), and from multiple computing devices (2000 onwards) towards invisible computing (2010 onwards). Communication processes are also expected to change, from people talking to people, to people interacting with machines, to machines/devices/software agents talking to each other and to people. A third important shift is the one which presumes that interfacing with computing capabilities will become natural and intuitive, in contrast with current Graphical User Interfaces (GUI). In short, AmI promises to transform the role of information and communication technologies (ICTs) in society and ultimately, to transform the way people live, work, relax and use their leisure time. According to MILES *et al.* (2002, pp. 4-9), this is probably one occasion where the overused phrase 'paradigm change' is appropriate.

Such a compelling vision is reflected in a variety of terms that have emerged in recent years: ubiquitous computing, pervasive computing, disappearing computing, pro-active computing, sentient computing, affective computing, wearable computing and ambient intelligence. The different terms may imply a different focus and also a geographical preference, hence the term AmI is prevalent in Europe, while ubiquitous computing is more common in the USA and Japan. What is specific to AmI is that it is based on the convergence and seamless inter-operability between three key technologies: Ubiquitous Computing, Ubiquitous Communication, and Intelligent User Friendly Interfaces. Other projects might focus for instance on just one or two key technology domains.

The objective of this article is not only to situate and discuss the AmI vision, but also to identify and detail major challenges and bottlenecks for its realization. This is relevant since the European Union has set the principal focus for its FP6 Information Society Technologies (IST) programme on the creation of this AmI world, bearing in mind that these are next-generation technologies not (yet) on the market. As a result, this article also raises IST innovation policy questions for advancing the notion of AmI. It will do so by arguing the need for, and significance of, an everyday life perspective that confronts (potential) users with future visions and technologies. It will provide insights on what can be learnt from existing user research for advancing the AmI vision and its implications and applications in everyday life.

Visions of the future of technology in society tend to be shaped by what the technologies have to offer. They often suffer from technological determinism. The Ambient Intelligence vision claims to be different, i.e. 'human-centred'. It also proposes to embed IST RTD in its socio-economic and user context. In the following section of this article, the AmI vision is

analyzed. The first subsection gives insights into the context, origins and advocators of the AmI vision. The following subsection argues that the origins of the AmI vision are not only technological, as usually assumed, but also social and economic. We then take this point one step further by discussing how AmI initially addressed the trend towards technology deterministic technology vision building. More recently, Experience and Application Research Centres have been promoted by ISTAG to address the challenge of human-centred technology development.

The third section develops the notion of user involvement by looking at the results of ethnographic, qualitative research. It introduces the domestication approach as illustrative for such research. Such an approach reveals that power relations in everyday life need to be taken into account for advancing AmI. It also highlights the need to understand the difference between the physical and mental disappearance of computing and identifies a future challenge as finding a balance between the adaptability and rigidity of AmI systems and services. Other socio-economic and policy-related issues are related to the risk of an Ambient Intelligence divide and the need for tackling privacy, security and dependability as bottlenecks for the acceptance of AmI. The last section wraps up the plea of this article for radical everyday life perspectives on developing and implementing Ambient Intelligence in everyday life.

■ The Ambient Intelligence vision

The objective of this section is to understand the AmI vision. Its context and origins will consequently be discussed. It is argued that the vision is potentially different from earlier technology visions due to its explicit human/user-oriented claims. However, to realise their potential, AmI technologies need to be designed and prototyped by taking (potential) users seriously, meaning that the micro-context of their everyday life is taken into account.

Context of the AmI vision

A major step in developing the vision of Ambient Intelligence in Europe has come from the IST Advisory Group (ISTAG), a group of experts from industry and academia advising the IST RTD Programme of the European

Commission. ISTAG envisages a higher level of focus and a higher pace of development of ICTs in Europe. In 1999 it published a vision statement for the Fifth EC Framework Programme (FP5) to 'start creating the ambient intelligence landscape for seamless delivery of services and applications in Europe relying also upon test-beds and open source software, to develop user-friendliness, and develop and converge the networking infrastructure in Europe to world-class' [2]. Following this vision statement, AmI became broadly embedded in the FP5 IST work programme for 2000 and 2001. At the same time, a scenario exercise was launched with over 35 experts to develop a better understanding of the implications of an AmI landscape. This scenario report (ISTAG, 2001) – a key reference in the field – also identified major key technologies, socio-political issues and a research agenda for AmI [3].

ISTAG continued to develop the vision of AmI in preparation for the sixth RTD Framework Programme (FP6). Its report was published in 2002 at a time when confidence in the ICT sector had been shaken by the burst of the dot-com bubble, by the events of September 11th and by a more economic general slow-down. As a result, ISTAG argued for an urgent need for targeted and far-sighted investments in ICTs. FP6 needed to be a-cyclical: 'Those who will come out strongly during the next "upturn" will be those who have maintained their investment in innovation during the present phase of the cycle' (ISTAG, 2002, pp. 3-4).

Following the work of ISTAG and of other consultative procedures organised by the European Commission, AmI became the key concept in the FP6 IST programme for the period 2002-2006. The overall vision is that the IST thematic priority contributes directly to realising European policies for the knowledge society as agreed at the Lisbon Council of 2000 and as reflected in the e-Europe Action Plan. The strategic goal for Europe in the next decade is 'to become the most competitive and dynamic knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion'. This requires wider adoption, broader availability and an extension of IST applications and services to all economic and public sectors and society as a whole (EC, 2002, pp. 4-6).

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2 See www.cordis.lu/ist/istag.htm.

3 The scenario exercise was carried out in collaboration with the DG JRC Institute of Prospective Technological Studies (IPTS). For an overview of different scenarios exercises on the future of IST see: POPPER R. & MILES I. with GREEN L. & FLANAGAN K. (2004) Information Society Technologies Futures Forum: Overview of selected European IST scenario reports, PREST for the FISTERA project D1.1, http://fistera.jrc.es.

To make this possible, AmI is seen as a key concept. With ISTAG and the EU IST RTD funding programme (EUR 3.6 billion for 4 years versus EUR 16 billion for FP6 as a whole [4]) considerable efforts are being made in the EU to mobilise researchers and companies towards realising the building blocks for an AmI landscape. Other pan-European and national R&D programmes on AmI also exist, such as the ITEA consortium and the UK EQUATOR Interdisciplinary Research Collaboration [5]. The AmI vision is consequently gaining momentum. Focusing resources on a common project will possibly lead to greater economies of scale, while avoiding fragmentation and duplication of efforts. It might, however, exclude alternative visions.

The AmI vision originated in both social and technological factors

AmI is usually seen as the product of an exclusively technological evolution, but this subsection argues that it is more of a specific constellation of social - defined in its broadest sense - and technological factors that have enabled AmI to become an effective vision of the future, rather than pure science fiction.

In terms of technology, progress in three domains, i.e. microelectronics, communication and networking technologies and intelligent agents/user interfaces has given rise to the idea of AmI. Microelectronics in recent decades has been driven by Moores' law indicating the increasing capacity of computing power and storage at fixed costs. Cheaper, smaller and faster computing capabilities make it possible for computing functionalities to be embedded in potentially every object or device. Progress in communication and networking technologies has enabled the idea that these widely distributed computing devices could become networked or connected to one another. Breakthroughs in mobile, wireless and fixed (broadband) communication networks have increased the capacity (bandwidth), speed and availability of communication networks. Computing devices have also become user-friendlier with the introduction of the GUI.

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4 *Official Journal of the European Communities*, 29.8.2002, Decision no. 1513/2002/EC of the European Parliament and of the Council of June 27th 2002 concerning the sixth framework programme of the European Community for research, technological development and demonstration activities, contributing to the creation of the European Research Area and to innovation (2002 to 2006).

5 See http://www.itea-office.org; www.equator.ac.uk.

First generation intelligent agents, i.e. personal software assistants with a certain degree of autonomy have also been developed. Examples of existing agents are (personalised) e-mail alert agents informing the user about news, offers, events or changes (e.g. My Yahoo!).

Technological progress in all these fields has helped shape the AmI vision, but progress in the diffusion and acceptance of past and current ICTs has played an equally important role. In the last 10 years mobile telephony in Europe has grown into a market of over 300 million users. In many European countries, mobile telephony penetration rates of are above 70% of households. SMS has also given a considerable boost to the mobile services market in recent years. Residential internet access increased to 40% in the EU15 in June 2002, versus 28% in October 2000 (Eurobarometer, 2002). If the increased diffusion and usage of computer, the internet, mobile phones and PDAs had not happened, technological progress in the fields of microelectronics, communication technologies and intelligent agents/user interfaces would certainly have slowed down.

Acceptance of these technologies is enabled by demographic and social trends such as individualism, diversity, mobility and the choice of personal life styles, affecting the structure of groups and communities, as well as the ways we live and work. Mobile phones, for instance, are enablers of lifestyles that are increasingly individual and mobile. Household structures (family size and composition) are changing too, with a decline in traditional nuclear families and an increase in dual income households and single parent/single person households (DUCATEL *et al*., 2000; GAVIGAN *et al*., 1999). ICTs are expected to be instrumental in coping with the effects of these changes.

The point is that, despite the technological progress made, the idea of AmI may possibly not have existed at all if many of the existing ICTs had not been taken up by a consumer market driven by demographic and social trends. Moreover, many of the so-called technological advances are only enabled the specific socio-economic context in which they are developed. Take the example of Moores' law. This is typically seen as a technological prophecy, but as TUOMI (2002) argues, the prophecy could only hold because of the unique economic and social conditions in which the semiconductor industry has operated in recent decades. Moores' law alone was not responsible for that. Another example is the European success of GSM. Technological progress has enabled this success, but European efforts to agree on a common standard, the Global System for Mobile communications, undoubtedly contributed to its success. As these examples

illustrate, AmI is not only about technological progress. For a full understanding of AmI, such non-technological or rather socio-economic issues need to be made more explicit.

The ISTAG focus on human-centred development of AmI

AmI is more a vision of the future than a reality. In common with earlier visions of the role of technology in society, it promises a better, faster and happier world. This also applied to discourses surrounding the launch of the telegraph, telephone, radio, television and mechanical household appliances (for their histories see: FLICHY, 1995; MARVIN, 1988; FORTY, 1986). Every time a new technology pops up, revolutionary social changes are promised and promoted. The problem with these visions is that they are, for the most part, technologically deterministic. Technologies are supposed to impact directly on society by causing social change (for the better). They only look at what is technologically feasible and ignore the socio-economic context and user dynamics that are shaping the innovation process as well. The present question is whether the AmI vision is able to escape technological determinism and thereby avoid one-sided promises of a better world.

Right from the start, the AmI vision focuses on people, not technologies. The visions of people benefiting from services and applications supported by new technologies in the background, and of people interacting via intelligent user interfaces were essential to ISTAG, according to its report. The experts involved in constructing the scenarios emphasised that people, potential users, were to be given the lead in the way systems, services and interfaces are implemented (ISTAG, 2001, pp. 3, 11-12). At the level of discourse, this is probably what makes AmI different from earlier technology visions.

The four scenarios that were developed in the 2001 ISTAG report underscored this view. They contrasted applications that served to optimise efficiency (whether in business or in society) against those that emphasised human relationships, sociability or just having 'fun'. They also underlined the place of AmI in serving society and supporting the community, as well as individuals. The scenarios sketched out different design emphases and pathways towards AmI, but their common ground was situation at the human interface. This emphasised a key feature of AmI, namely that technologies should be fully adapted to human needs and cognitions. It could be argued that AmI consequently represents a step beyond the current concept of a 'User Friendly Information Society' (*ibid*, pp. 16-17).

The observation that the scenarios were to focus on the human should not be understood to mean that AmI is only about individuals. It is also intended to be about IST support for manufacturing and the production of goods and services through, for instance, virtual enterprises. To elaborate on that point, in 2002, ISTAG introduced the notion of Ambient Intelligent Space, that is, the seamless connection and interoperability between different AmI environments such as home, work, school and car.

The individual is expected to move through these environments expecting seamless services. AmI Space interacts with the user, knows how to model user behaviour, controls the privacy and security of the transferred personal data and deals with authorisation, key and rights management. It should also ensure the quality of services as perceived by the user. ISTAG has realised that all of this is not trivial, and certainly not only technical. There is a perceived need for a combination of applications, services and infrastructure to realise AmI: 'More is needed than more technology' (ISTAG, 2002, pp. 15-22).

This is confirmed in the 2003 revision and updating of the AmI vision. In 2003 ISTAG still believed that AmI could only be fully developed by a holistic approach encompassing technical, economic and social research. It should not just consider the technology, but the complete innovation supply-chain from science to end-users, while taking into account the various features of the academic, industrial and administrative environment facilitating or hindering the realisation of the AmI vision. Moreover, it is not seen to be necessary to define the term AmI more precisely. It should be regarded and promoted as an 'emerging property' rather than as a set of specified requirements (ISTAG, 2003a, pp. 12-13).

In short, the ISTAG vision strongly emphasises the need for AmI to be driven by humanistic concerns, in contrast with the technologically deterministic tendency of mainstream vision building. However, given its raison d'être, ISTAG argues that neither ISTAG nor the IST research community should shrink from AmI's exciting possibilities. AmI, it insists, represents a new paradigm for citizens, administrations, governance and business. Radical social transformations are expected from its implementation. Although AmI is not a panacea for social problems, it could offer innovative ways to address the fundamental socio-economic challenges that Europe will face in coming years, such as its increasing number of customers and citizens, population growth and increased mobility (ISTAG, 2003a). The ISTAG vision positions itself carefully between technological determinism and societal reductionism. It remains to be seen,

however, if and how the vision will further influence the research, development and design of AmI applications. This issue is tackled in the next section.

User-oriented design

There are many different approaches to user-oriented design, i.e. to designing new technologies by taking into account user requirements and user behaviour in one way or another. The design guidelines proposed by ISTAG (2001) in its scenario exercise are situated at the generic socio-cultural, economic and political level. They provide some guiding principles for how technologies 'should' be designed. AmI should, for instance, facilitate human contact and be oriented towards community and cultural enhancement, while inspiring trust and confidence.

Usability research is situated at the more concrete human-machine interaction level, as it looks at applying some of the above mentioned design guidelines. The ISO 13407 'Human-centred design for interactive systems' standard requires human-centred design to actively involve users; to clearly understand and use task requirements, to appropriate the allocation of functions, to use the iteration of design solutions, and to set up a multi-disciplinary design team. Another design standard that is promoted by the European Commission is 'Design for All'. This aims to increase the accessibility of information technology products, mainly for people with disabilities [6]. Most of these activities are based on functional translations of user requirements. They are mainly rooted in the traditions of behavioural science and computer engineering, but efforts are increasingly being made to bridge both worlds and to take users seriously, especially within the fields of Human Computer Interaction (HCI), Computer Mediated Communication (CMC) and Computer Supported Cooperative Work (CSCW) [7].

This constitutes a first logical step, but the real challenge may be to involve users in a sociological sense, namely by accounting for the micro-context of their everyday lives (PUNIE, 2003). In its latest reports, ISTAG (2003a, 2003b) also acknowledges this challenge and proposes the concept

[6] http://www.iso.org; http://www.usabilitynet.org/tools/13407stds.htm; http://www.ucc.ie/hfrg/emmus/methods/iso.html; http://www.e-accessibility.org

[7] See for instance: http://www.bcs-hci.org.uk/hci2004; http://www.ascusc.org/jcmc; http://www.acm.org/cscw2004 /

of EARCs as a possible way of addressing it. Experience and Application Research Centres (EARCs) are proposed as a new approach to the prototyping necessary for the successful development of AmI products and services. Functional, technical, social, economic and cultural requirements of systems gathered from users and stakeholders need to be put at the centre of the development process, revisited through design, implementation, checking and testing. Experience prototyping can be used to understand user experiences and their contexts, to explore and evaluate new designs and communicate ideas to designers and stakeholders. This should 'allow people to live in their own future' and should bring AmI research closer to the needs of citizens and businesses (ISTAG, 2003a, p. 5).

The EARC approach is challenging and extends well beyond current engineering and design approaches. It provides multi-dimensional strategies for involving users in the design process by responding to the growing recognition that acceptance of ICTs is not only shaped by their technological possibilities or by their functionality, but also by the micro-social context of the household or of other social settings (ISTAG, 2003a, p. 29). The EARC approach seems to favour more in-depth studies of users, but also recognises that user studies vary according to when users are consulted in the innovation process. A distinction is consequently made between:

- science and technology centres for basic research on component technologies for AmI (with little user input);
- feasibility and usability centres for basic (small scale) users research on the integration of AmI technologies and systems into real user environments (e.g. living labs);
- demonstration and evaluation centres for (large scale) user research whereby prototypes are integrated into large-scale demonstration facilities (e.g. smart home demonstrators);
- field trials for small and large-scale longer-term studies of technologies and systems undertaken with users in their real life environments (e.g. home, work, airport, hospitals, etc.) (ISTAG, 2004, p. 14).

The way user research is conducted and the kind of results that can be expected depend on where user research is located in the innovation process. More research is needed to map user studies and to highlight the pros and cons of each of these stages of user research. Yet it can already be argued that a lot of variation can be expected, even within each stage. Ethnographic research on ICTs in the home environment, for instance, can be oriented towards design or can have broader sociological objectives.

Small-scale ethnographic research has been carried out on domestic routines, for instance, and the way such practical routines can influence the design of new ICT technologies in the home (RODDEN & CRABTREE, 2004; CRABTREE, 2003). The research focused on the specific case of the way incoming and outgoing mail is organised in the home. Mail is purposefully placed in the household at different locations depending on what needs to be done. This is described as an "ecological network of displays" constructed by household members to coordinate the actions occasioned by the arrival of mail. The introduction of digital media to support the handling of mail would need to be very flexible and would need to take into account these complicated patterns of displaying and moving of mail objects around the home.

This study also confirms that human-machine interaction is not just about a simple relation between an individual user and an individual artefact. User research needs to go beyond the usual focus on individual users, especially when taking into account that AmI products and services will be intelligent, adaptable and networked, in contrast with stand-alone products. As TUOMI (2003) argues, machines are to be seen as media that connect systems of social activity. This means that designing a product actually means designing the structures for social interaction. The problem of design cannot be reduced to abstract functionality (engineering), nor to aesthetic considerations (design) or to usability design. There is a gap to be filled by refining design methodologies that take the social foundations of product use into account.

These social foundations are also shaped by socio-cultural routines and habits. The ethnographic approach that will be presented in the next sections focuses on these routines. As will be demonstrated, the orientation of this ethnographic research is, however, more sociological then design-oriented.

■ Ambient Intelligence and daily life

Domestication is an approach for studying the information society from the users' point of view by focusing on the acceptance of, or resistance to ICTs within the context of everyday life (MERETE & SØRENSEN, 1996; SILVERSTONE & HADDON, 1996; SILVERSTONE, 1994). Domestication studies are field trials of users in their natural environment. Domestication refers to

the capacity of individuals, families, households and other institutions to bring new technologies and services into their culture, to make them their own. In this approach, the users take part in the process of shaping ICTs through making meaning of/with them, and integrating them into their everyday lives, their social networks, their ideas about themselves and their value-systems.

Domestication finds its origins in social-constructivist approaches to science and technology, in audience and user research in media studies and in the sociology and anthropology of everyday life. Qualitative research methodologies are usually applied within a domestication approach, while other approaches such as diffusionism tend to prefer quantitative methods (e.g. ROGERS, 1995).

It is the objective of section three to take insights from domestication studies on existing and past technologies as a basis for considering how they can be used to advance thinking on future technologies. Such an everyday life approach is especially relevant for looking at Ambient Intelligence since one of its central claims is indeed to place the user, in its context, at the centre of development.

Power relations and daily home life

By taking an everyday perspective on acceptance and use of ICTs, domestication studies look at how technologies are negotiated within the household and/or more general contexts of everyday life structures and patterns. Such a perspective implies that the enactment of structural power relations of class, gender, age, ethnicity and others should be taken into account, based on sociological theories of social stratification. Domestication would argue that social activities are not completely determined by these power relations (structural determination), nor that they are completely absent (individual freedom), but rather that these power relations are negotiated within the regularities and irregularities of everyday life (PUNIE, 2004).

Gender studies, for instance, illustrate how socially and culturally prescribed roles of masculinity and femininity shape differences in attitudes, acceptance and use of ICTs. A typical example is the remote control (TV, VCR) that is handled – in many households – primarily and sometimes exclusively by men (the father and/or the son). It is seen as a visible symbol of ICT related masculine power in the household, where the men determine

and/or decide over possible family viewer conflicts (LULL, 1988). Gender also shapes ICT competences and skills. GRAY (1992) provides empirical accounts of woman using very sophisticated pieces of domestic technology, i.e. the so-called white goods (e.g. microwave, washing machine), while at the same time not being able to operate electronic brown goods (e.g. VCR). This is sometimes the result of a deliberate, strategic choice not to be able to use ICTs, labelled by Gray 'calculated ignorance' as a strategy of division of labour in the household.

These examples may now seem a bit outdated, but they do indicate that use and acceptance of ICTs are negotiated within power relations of the household, be it gender, age, class, ethnicity or combinations of these. With future Ambient Intelligence systems and services in everyday life, these structural relations will persist, although probably in different forms. This argument can be explored through two examples: the absence of housework in the notion of everyday computing and the notion of intelligent agents as social actors.

Everyday computing and housework

'Human centred computing' and 'everyday computing' is exactly about supporting and enhancing everyday tasks, the informal and unstructured activities typical of much of our everyday lives. Familiar examples are orchestrating tasks, communicating with family and friends and managing information. Designing for everyday computing requires addressing these features of informal, daily activities (ABOWD & MYNATT, 2000, pp. 30-31).

However, a particular type of everyday activity in the home, namely housework, is rarely considered. This is surprising since housework (e.g. cleaning, washing, ironing) is still one of the most repetitive and time-consuming tasks to be executed in the home. There are exceptions. The 'intelligent vacuum cleaner', for instance, is already for sale. Scenarios describing an intelligent washing machine communicating with the intelligent clothes it is washing also exist, but in general, housework seems to be relatively absent in visions and projects about the future of computing. Feminist research on smart homes in Norway at the beginning the 1990s observed a similar trend (BERG, 1996, pp. 87-89). Ethnographic research into the daily life thus highlights that housework occupies a central place in everyday existence and that power relations are exercised around it. However, as far as the notion of everyday computing is concerned, it seems to be invisible.

Intelligent agents as social actors

The crosscutting idea for many of the AmI projects and applications is context awareness, currently based primarily on the identification of the user and his/her location. Context awareness renders AmI applications, to a certain extent, smart since they adapt their behaviour based on information sensed from the physical and computational environment. Intelligent agents are central to context-aware services and to AmI in general.

Current descriptions of both context awareness and intelligent agents tend to present them as neutral, i.e. not needing to adopt a position within social relations. This will be difficult to sustain when confronted with users and non-users in their everyday life, since the latter are not at all neutral. As argued above, everyday life is shaped by an individual's socio-economic position (class, gender, and ethnicity), his/her personal history (parents, education, etc.) and symbolic position in society. Social capital also plays a role here (van BAVEL *et al*., 2004). Since intelligent services are pro-active, they have to present certain choices and/or take some decisions for users, therefore preferring certain options above others. This runs the risk of causing problems and even conflicts in everyday life. Preliminary results of a living lab experiment called 'Ambient Intelligence Homelab' confirmed this. The intelligent agent dealing with entertainment schedules was criticised by the son because it favoured the preferences of his father. Can intelligent agents take a just or egalitarian position within family relations? Who will be to blame for unequal access within the family?

RIEDER (2003) argues that intelligent agents should not only be regarded as software programmes, but also as 'social actors' since they inevitably take a position. Agents present a certain view on the world. Making the machine more subjective and thus bringing it closer to everyday life is exactly the objective of new generations of agents under development. There is a risk, however, that agents' functioning becomes a new 'black box', since it is not obvious how it understands the algorithms used to get certain results. How will users be informed of this process? And what is the position of authority of agents' results? Are they exclusive or better than other sources of information? It is clear that social and user-oriented research is needed to better understand the position of intelligent agents in everyday life. They can not be neutral since it is precisely because they are not neutral that they will be intelligent.

The disappearance of computing

At the core of Ambient Intelligence is the idea that computing becomes invisible by embedding it in the environment and everyday objects. Computing should be in the background, in the periphery of our attention and should only move to the centre if necessary; hence the existence of EU RTD programmes such as 'the disappearing computer'. At first sight, there is a striking parallel with the domestication approach. Ultimately, technologies are domesticated when they are 'taken for granted', when they reach a state of mind of being a 'natural' part of everyday life. As such, they are no longer perceived as technologies, as machines, but rather as an almost natural extension of the self. By claiming to move technologies to the background and people to the foreground, Ambient Intelligence promises a disappearance of the technical artefact and its underlying technologies. As a result, it can be seen as the ultimate stage of domestication.

However, domestication also highlights that the process of acceptance and use of ICTs is not necessarily harmonious, linear or complete. Rather it is presented as a struggle between the user and technology, whereby the user aims to tame, gain control, shape or ascribe meaning to the technological artefact. This does not signal resistance to a specific technology, but rather an active acceptance process. The material invisibility of technological artefacts – aimed at through miniaturisation and/or embedding – may well harm, rather than facilitate their acceptance. Exactly because they are invisible, they become uncontrollable. Making technologies disappear, while assuming that they will reduce tensions, could, on the contrary, make them insoluble. There is a difference between the physical and mental disappearance of computing, and it is incorrect to assume that physical disappearance will lead automatically to acceptance and use, and thus to mental invisibility.

Adaptive computing

Studies of technological innovations have indicated an important difference between the intended use of ICTs by its designers and their real, effective use by users. Users and uses are pre-configured in the design of ICTs. This pre-configuration shapes the way ICTs will be used to a certain extent. One cannot leave this frame as a user, but there is freedom to experiment with ICTs, to invent new uses and to make them their own (FLICHY, 1995). Users take up this activity. This can lead to surprises, such

as the recent success of SMS, which was not expected by the technology designers. Another typical example is the French Minitel of the 1980s. This videotext system was set up to be used as an informational service but the French users 'invented' another, more successful use, i.e. communication and erotic services (BOUWMAN & CHRISTOFFERSON, 1992). The telephone answering machine is also used in a way not originally foreseen, i.e. for screening incoming calls, and thus actually for increasing un-accessibility instead of accessibility (FRISSEN & PUNIE, 2001).

These studies highlight that for ICTs to become accepted, there needs to some degree of flexibility for users to experiment and find their own uses. With AmI this degree of flexibility can be increased significantly because new services will be driven by software and thus be programmable. Re-programming might become possible both for developers and for users. This is partly incorporated in the idea of adaptive computing whereby devices and services have a high degree of heterogeneity. Their functions and possibilities are changeable on the basis of user preferences. Truly personal devices will become possible (e.g. ISLAM & FAYAD, 2003). Philips calls such an approach 'open tools' (AARTS & MARZANO, 2003, pp. 338-339).

Multimodal appliances are also envisaged. A cellular phone can be used as a remote control, for instance. This does not mean one device will do everything, but that there will be different devices that can handle multiple media related to their specific task. Standards for interoperability will be essential in this context (ITEA, 2001, p. 59).

Devices and services that are completely open to users or that are completely adaptable may face the risk, however, of becoming unusable or unappealing for users. Certain degrees of flexibility are necessary but pre-configured uses and users are also needed for potential users as guiding forces. They reduce the complexity and uncertainty that typically emerge when users are confronted with innovations. They also help users understand what is new about innovations. A challenge for adaptive computing and for AmI in general is to find an acceptable balance between openness and adaptability versus user guidance and rigidity.

An Ambient Intelligence divide

According to the Lisbon European Council of 2000 and the e-Europe 2005 Action Plan, the European Union is committed to developing, amongst others, 'an information society for all' 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 notions of the digital divide on the policy agenda. It is of concern to policy makers that (new) technologies should not become a (new) source of exclusion in society.

The term 'digital divide' is used and defined in many different ways. It can be observed between regions (e.g. north and south), nations, companies, households and individuals (within nations and across nations, with or without disabilities). Research also suggests that the digital divide is not just a question of access to telecommunications and ICT services (such as the internet), but also of skills, competencies, appropriate content, access to the necessary resources (e.g. time and money) and different ways of using ICTs. Voluntary exclusion is also to be taken into account (for an overview see: CAMMAERTS *et al*., 2004).

Although the diffusion and penetration of ICTs in Europe, especially of the internet and mobile phones, have increased substantially during the last years, recent empirical data confirm the persistence of digital divides at different levels (e.g. CORROCHER, 2002; Eurobarometer, 2002; de HAAN *et al*., 2002). At the individual and household level, differences in ownership and usage of ICTs still seem to exist, for instance, between the younger and the older, and between higher educated financially well-off families and lower educated, poorer families.

Socio-economic criteria (age, sex, education, income, family composition) influence not only user acceptance, but also users' attitudes towards, and knowledge of, new technologies, as well as their available resources (time and money) (e.g. PUNIE, 2004; FRISSEN & PUNIE, 2001). Although women are catching up, gender differences persist in ICT usage, both in terms of quantity (e.g. time spent on the internet) and in terms of quality (e.g. the way ICTs are used).

Ambient Intelligence, however, promises to remove some of the existing barriers to the acceptance of new technologies. It challenges current thinking on the use and acceptance of ICTs. AmI, indeed, addresses certain issues that are at the core of the digital divide debate, i.e. user-friendliness, relevant (context-aware) services and natural interfaces. The latter, for instance, envisage human-machine interactions that will become more like the way humans interact with each other in the real world (via speech, gesture, touch, senses). It is thought that this evolution away from desktop graphical interfaces would make it easier and faster for everyone to learn to use

ambient devices and services (e.g. ISTAG, 2002, p. 29), thus enabling them to attract the non-users who today lack the skills and competences to use ICTs.

Even if AmI is adapted for people and even if AmI facilitated interaction consequently proves relaxing and enjoyable for individual citizens and consumers, it is difficult to believe that AmI will be able to appeal to all groups in society, certainly not in a similar way and at the same time. Given socio-economic differences and individual preferences, there will probably always be 'early adopters' and 'late adopters', and even people who will resist Ami. Although AmI puts a huge emphasis on its user orientation, there are no guarantees that users will indeed embrace AmI in the way it is proposed or developed today.

Moreover, new and other concerns possibly, affecting universal access to, and use of, AmI services and devices are likely to emerge. New skills, competences and types of literacy may emerge. They could include content selection, content interpretation and creative and innovative thinking (BOGDANOWICZ & LEYTEN, 2001). ISTAG (2001) sees new skills arising in relation to social know-how and information manipulation. As AmI increases means of personal expression and interaction, users will need to learn how to deal with digital identities and intelligent agents. This also raises concerns over the protection of privacy. The question is 'whether people will be able to adapt to the feeling that their environments are monitoring their every move, waiting for the right moment to take care of them' (AARTS *et al*., 2002, p. 249). The threat of the invasion of one's privacy might indeed be one of the barriers to AmI's social acceptance.

Privacy, security, surveillance and dependability

As our lives, homes, cars, neighbourhoods, cities and other environments become increasingly digitized and connected, more and more personal information will be digitally gathered, stored and possibly disclosed to other sources, services, institutions and/or persons. Such intrusion concerns 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).

With Ambient Intelligence, the monitoring and surveillance capabilities of new technologies can be massively extended beyond the current credit-card and shopping records (e.g. consumer loyalty cards), Internet logs (e.g. e-mail, news postings, discussion forums) and detailed phone invoices. This is possible not only because this intelligent environment is able to detect and monitor constantly what people are doing in their everyday lives, both off-line and on-line, but also because of the possibility of connecting and searching isolated databases containing personal information. Some argue it might even mean the end of privacy (GARFINKEL, 2001). It will be very difficult for people to find a place where they can hide themselves, where they will have 'the right to be left alone', the latter being one of the first (liberal) definitions of privacy developed by Samuel WARREN & Louis BRANDEIS (1890).

Monitoring and surveillance techniques create new opportunities for so-called 'border crossings' between what is public and what is private. The problem is that with new AmI technologies, the crossing of these borders becomes easier and possibly more likely. AmI also 'needs' to contain historical and current data about individuals' preferences and activities (user profiles) in order to deliver context-dependent, value added, pro-active services. A crucial, but inevitable trade-off between having privacy of certain personal information and receiving convenient, efficient services will have to be made (e.g. SRI, 2003).

However, without effective privacy protection measures, this brave new world of smart environments and interconnected objects could become an Orwellian nightmare (MATTERN, 2004; BOHN *et al.*, 2003; ISTAG, 2001). Addressing the balance between privacy and security will be a core challenge for the future of Ambient Intelligence. For people to feel at home within AmI, it needs to be able to represent their multiple identities, respect their privacy and establish an acceptable level of security (BESLAY & PUNIE, 2002).

Technology can do a lot to protect privacy, but in reality, 'it can only safeguard privacy. Figuring out what the safeguards ought to be, and where our zone of privacy actually lies, is a matter of policy, law, and ultimately, social norms' (WALDROP, 2003). Legal and social questions have to be dealt with in relation to the control and management of the information that is collected about an individual and how that information is going to be used. Concerns about privacy are part of larger concerns about control, about people having control over their own lives.

■ Ambient Intelligence and the need for more in everyday life

This article has identified some major challenges and bottlenecks for Ambient Intelligence in everyday life. It has explored key questions for advancing AmI from a qualitative and critical everyday life perspective. The way Ambient Intelligence in Europe is being developed is very promising. The AmI vision explicitly aims to avoid two pitfalls that are common to technology vision building, i.e. technology determinism and rhetorical claims of promising a better world. It recognises the need for AmI to be driven by human, rather than technological concerns, and it proposes human-centred design and development guidelines together with other social concerns in order to advance this process.

Experience and Application Research Centres (EARCs) are a new approach promoted by ISTAG to take into account functional, technical, social, economic and cultural requirements via prototyping. This should 'allow people to live in their own future' and should bring AmI research closer to the needs of citizens and business. EARCs seem to provide a promising way forward by embedding IST RTD in its socio-economic and user context. However, it remains to be seen how EARCs will be implemented and how different levels of user research will reveal different results depending on their location in the innovation process. There are many differences, even within ethnographic approaches to the home, some being more oriented towards design and others towards a critical sociological underpinning of technology development. Taking the micro-social context of everyday life seriously would mean that power relations such as class, gender, age and ethnicity are taken into account in the ICT innovation process, and in future studies and vision building. Such an approach would reveal, for instance, that although the home of the future may bring a lot of advantages, it also the place where power relations and inequalities are fought out. Such an approach also highlights that certain ideas have yet to be included within the framing of AmI, such as housework. This particular type of continuous and time consuming everyday work at home is rarely touched upon in claims about human centred and/or everyday computing, nor does it seem to be prevalent in RTD projects.

It will also be needed to see intelligent agents as social actors that inevitably take position in social relations, while current descriptions of both context awareness and intelligent agents tend to present them as neutral. This will be difficult to sustain when confronted with users and non-users in

their everyday life. There is a need for social and user-oriented research to better understand the position of intelligent agents in everyday life in order to avoid agents becoming a new 'black box' in society.

Ambient Intelligence promises the 'disappearance' of computing as an object by embedding computing intelligence in the environment and in everyday objects. Ethnographic research says that technologies and technological artefacts are domesticated when they are 'taken for granted'. There is a substantial difference between these two perspectives, however. AmI assumes the material or physical disappearance of computing, while domestication refers to the mental invisibility of the technology. The two might exist together, but not per se: physical disappearance will thus not automatically lead to mental disappearance and hence to smooth acceptance and use of AmI. The former may even harm rather than facilitate acceptance, precisely because AmI is invisible, and thus difficult to control.

Another challenge facing AmI is to find an acceptable balance between adaptability versus rigidity. Devices and services that are completely open or adaptable may run the risk of becoming unusable or unappealing to users. Certain degrees of flexibility are necessary, but pre-configured uses and users are also needed to guide potential users. They reduce the complexity and uncertainty which typically emerge when users are confronted with innovations. They also help users understand what is new about innovations, while completely open tools risk leaving them without direction.

The risk for a digital, or rather AmI divide, is also an important issue. It is difficult to anticipate or predict the possible acceptance of AmI, and although AmI promises to remove some of the current barriers for the acceptance of new technologies, it is unlikely that AmI will appeal to all groups of society. Socio-economic and cultural resources are unequally distributed in society and personal preferences differ as well. Moreover, new skills and competencies are likely to emerge resulting in different degrees of acceptance and possibly also rejection.

There are also major concerns over the protection of privacy. The privacy invasive potential of AmI might indeed be one the barriers in the social acceptance of AmI. The dilemma is that AmI can not deliver context-dependent, value added, pro-active services without containing historical and current data about an individual's preferences and activities (user profiles). A crucial, but inevitable trade-off between keeping certain personal information private and receiving convenient, efficient services will have to be made.

References

AARTS E., HARWIG R. & SCHUURMANS M. (2002): 'Ambient Intelligence', in Denning P. (ed.), *The invisible future. The seamless integration of technology in everyday life,* New York: McGraw-Hill, 235-250.

AARTS E. & MARZANO S. (eds.) (2003): *The new everyday. Views on Ambient Intelligence*, Rotterdam: 010 Publishers.

ABOWD G. & MYNATT E. (2000): 'Charting past, present, and future research in ubiquitous computing', ACM Transactions on Computer-Human Interaction, 7(1), March, 29-58.

BEIGL M., GELLERSEN H-W. & SCHMIDT A. (2001): 'Mediacups: Experience with design and use of computer-augmented everyday artefacts', Computer Networks, 35(4), March. http://www.comp.lancs.ac.uk/~hwg/

BERG A-J. (1996): "Digital feminism", Rapport no. 28, Centre for Technology and Society, Norwegian University of Science and Technology, Trondheim.

BESLAY L. & PUNIE Y. (2002): 'The virtual residence: Identity, privacy and security', The IPTS Report, Special Issue on Identity and Privacy, No. 67, September, 17-23.

BOGDANOWICZ M. & LEYTEN J. (2001): 'Sympathy for the cyborg: Research visions in the information society', Foresight, 3(4), 273-283.

BOHN J., COROAMÃ V., LANGHEINRICH M., MATTERN F. & ROHS M. (2003): 'Disappearing Computers Everywhere. Living in a World of Smart Everyday Objects', Paper for the EMTEL Conference, London 23-26 April 2003. www.inf.ethz.ch

BOUWMAN H. & CHRISTOFFERSON M. (eds) (1992): *Relaunching Videotex*, Dordrecht/Boston/ London: Kluwer Academic Publishers.

CAMMARTS B., van OUDENHOVE L., NULENS G. & PAUWELS C. (eds) (2004): *Beyond the digital divide. Reducing, exclusion, fostering inclusion*, Brussel: VUBPress.

CORROCHER N. (2002): 'Internet diffusion dynamics in Europe: demand scenarios and the digital divide', STAR Issue Report no. 29, Databank Consulting. www.databank.it/star

CRABTREE A. (2003): *Designing collaborative systems: A practical guide to ethnography*, London: Springer-Verlag.

CRABTREE A. & RODDEN T. (2004): Domestic routines and design for the home, *Computer Supported Cooperative Work: The Journal of Collaborative Computing*, Pre-print article: www.kluweronline.com/issn/0925-9724.

de HAAN & HUYSMANS F. in collaboration with BECKER J., BREEDVELD K., de HART J. & van ROOIJEN M. (2002): *E-cultuur: Een empirische verkenning*, Den Haag: SCP.

DEWSBURY G., TAYLOR B. & EDGE M. (2001): 'The process of designing appropriate smart homes: including the user in the design', Paper presented at the 1st Equator IRC Workshop on Ubiquitous Computing in Domestic Environments, University of Nottingham, 13-14th September 2001. http://www.equator.ac.uk

DUCATEL K., BURGELMAN J.-C., SCAPOLO F. & BOGDANOWICZ M. (2000): 'Baseline scenarios for Ambient Intelligence in 2010', IPTS Working paper, Sevilla, EC DG JRC.

Eurobarometer (2002): 'Internet and the public at large', Flash Eurobarometer 125, Eos Gallup upon request of the EC, DG Information Society, July 2002, Brussels: European Commission.

European Commission (EC) (2002): 'Information Society Technologies. A thematic priority for Research and Development', under the Specific Programme "Integrating and strengthening the European Research Area" in the Community sixth Framework Programme, IST Priority, WP 2003-2004', EC: Luxembourg. http://www.cordis.lu/ist

FLICHY P. (1995): *L'innovation technique. Récents développements en sciences sociales. Vers une nouvelle théorie de l'innovation*, Paris: Editions La Découverte.

FORTY A. (1986): *Objects of desire. Design and Society 1750-1980*, London: Thames & Hudson.

FREED K. (2002): 'American cable adopts Europe's iTV standard', www.media-visions.com/itv-openmhp.html.

FRISSEN V. & PUNIE Y. (2001): 'Present users, future homes. A theoretical perspective on acceptance and use of ICT in the home environment', Delft: TNO-STB Paper, May 2001.

GARFINKEL S. (2001): *Database Nation. The death of privacy in the 21st Century*, OReilly Publishers.

GAVIGAN J., OTTISH M. & GREAVES C. (1999): 'Demographic and social trends Panel Report', Futures Report Series 02, IPTS, JRC, European Commission.

GRAY A. (1992): *Video Playtime: the gendering of a leisure technology*, London & New York: Routledge.

ISLAM N. & FAYAD M. (2003): 'Towards Ubiquitous acceptance of ubiquitous computing', Communications of the ACM, February 2003, 46(2), 89-91.

ISTAG:

- (2001): 'Scenarios for Ambient Intelligence in 2010', Edited by Ducatel K., Bogdanowicz M., Scapolo F., Leijten J. & Burgelman J.-C., IPTS-ISTAG, EC: Luxembourg. www.cordis.lu/ist/istag
- (2002): 'Strategic orientations and priorities for IST in FP 6', Report of the IST Advisory Group, EC: Luxembourg. www.cordis.lu/ist/istag
- (2003a): 'Ambient Intelligence: from vision to reality: For participation in society & business', ISTAG Consolidated Document, September 2003. www.cordis.lu/ist/istag

- (2003b): 'ISTAG in FP6: Working Group 1 on "IST Research Content"', Final Report, September 2003. www.cordis.lu/ist/istag
- (2003c): 'ISTAG in FP6: Working Group WG3 on "Research results exploitation"', Final Report, September 2003. www.cordis.lu/ist/istag
- (2004): 'Experience and Application Research: Involving users in the development of Ambient Intelligence', ISTAG Working Group Final Report Version 1, June 2004. www.cordis.lu/ist/istag

ITEA (2001): 'Technology Roadmap on Software Intensive Systems, Information Technology for European Advancement (ITEA)', ITEA Office Association, Eindhoven. www.itea-office.org/index.htm

LULL J. (ed.) (1988): *World Families Watch Television*. Newbury Park, CA: Sage Publications.

MARVIN C. (1988): *When Old Technologies were New. Thinking about electric communication in the late nineteenth century*, Oxford: Oxford University Press.

MATTERN F. (2004): 'Ubiquitous Computing: Scenarios for an informatized world', ETH Zurich, Paper to be published. http://www.inf.ethz.ch/vs/publ/index.html

MILES I., FLANAGAN K. & COX D. (2002): 'Ubiquitous Computing: Toward understanding European Strengths and Weaknesses', European Science and Technology Observatory Report for IPTS (EC DG JRC), PREST: Manchester, March 2002.

PUNIE Y.:
- (2004): 'Een theoretische en empirische benadering van adoptie, gebruik en betekenis van Informatie-en Communicatietechnologie in het dagelijkse leven', in Carpentier N., Pauwels C. & Van Oost O. (eds.), *Het on(be)grijpbare publiek: Een communicatiewetenschappelijke exploratie van publieksonderzoek*, VUBPress: Brussel, 175-200.
- (2003): 'A social and technological view on Ambient Intelligence in Everyday Life: What bends the trend?', European Media, Technology and Everyday Life Research Network, EMTEL2 Key Deliverable Work Package 2, September 2003, EC DG-JRC, IPTS, Sevilla. [EUR 20975]

RIEDER B. (2003): 'Agent technology and the delegation-paradigm in a networked society', Paper for the EMTEL Conference, London 23-26 April 2003. www.emtelconference.org

RIVA G., LORETI P., LUNGHI M., VATALARO F. & DAVIDE F. (2003): 'Presence 2010: The Emergence of Ambient Intelligence', in G. Riva, F. Davide, W.A IJsselsteijn (Eds.), *Being There: Concepts, effects and measurement of user presence in synthetic environments*, Amsterdam: Ios Press.

ROGERS E.M. (1995): *Diffusion of innovations*, New York: The Free Press (Fourth Edition).

SILVERSTONE R. & HADDON L. (1996): 'Design and domestication of information and communication technologies: Technical change and everyday life', in R. Mansell

& R. Silverstone (eds.), *Communication by design. The politics of information and communication technologies*, Oxford: Oxford University Press, pp. 44-74.

SRI (2003) 'Distributed Identities: Managing privacy in pervasive computing', SRI Consulting Business Intelligence, Explorer Viewpoints, May 2003.

TUOMI I.:

- (2003): 'Beyond user-centric models of product creation', Paper presented at the COST A269 Conference: the Good, The Bad and The Irrelevant, Helsinki, 3-5 September 2003.
- (2002): 'The Lives and Death of Moore's Law', First Monday, 7(11), November. http://firstmonday.org/issues/issue7_11/tuomi/index.html

van BAVEL R., PUNIE Y., BURGELMAN J.-C., TUOMI I. & CLEMENTS B. (2004): 'ICT and Social Capital in the Knowledge Society'. Report on a Joint DG JRC-DG Employment Workshop, Sevilla, 3-4 November 2003, Technical Report EUR 21064 EN, January 2004.

WALDROP M. (2003): 'Pervasive Computing. An overview of the concept and an exploration of the public policy implications', Paper for the Future of Computing Project, Foresight and Governance Project. www.thefutureofcomputing.org

WARREN S. & BRANDIES L. (1890): 'The Right to Privacy', in *Harvard Law Review*, Vol IV, No.5. http://www.lawrence.edu/fac/boardmaw/Privacy_brand_warr2.html.

WEISER M.:

- (1993): 'Some computer science issues in ubiquitous computing', Communications of the ACM, July 1993, Vol. 36, no.7, 75-84.
http://www.ubiq.com/hypertext/weiser/UbiCACM.html
- (1991) 'The computer of the 21st century', in *Scientific American*, September 1991, pp. 94-101.
http://www.ubiq.com/hypertext/weiser/SciAmDraft3.html.