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> We need to continue evangelising the vision throughout Philips and Europe in order to make it come true (Aarts, 2003: 5).

The AMI innovation narrative (preprint title)

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Abstract: The vision of Ambient Intelligence (AmI) was first developed in the late 1990s. It describes new worlds, economies and paradigms that emphasize the centrality of human experience, however, distinguished from related visions such as ubiquitous and pervasive computing. A key feature of the AmI vision are the seamless intelligent environments and gadgets, capable of anticipating people's needs and motivations, and acting autonomously on their behalf. So what can be gleaned from exploring the conditions under which this innovation domain evolves over time and how it adapts to various criticisms and technical challenges? The AmI vision not only represents possible futures but actively creates the worlds in which AmI applications appear to be possible. Visionaries and research leaders build expectations, marshal resources and align key stakeholders. Promises and progressions toward realizing AmI have performative and generative features but the original promise of *intelligence* has largely failed. This outcome points to a two-sided problem. The definitional looseness of *intelligence* is permissive of what can be expected of the role and scope of artificial reasoning in AmI interaction paradigms, while ordinary human reasoning and knowing what people actually want and need remains persistently elusive. Grappling still with the problem of what the *intelligence* in Ambient Intelligence can stand for, research and development has shifted its focus toward the design of practical win-win solutions, coined *synergetic prosperity*.

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Introduction

A vision of how Information and Communication Technologies (ICTs) will shape the everyday of the future was proposed in 1998 and coined as Ambient Intelligence (AmI). It depicts a world of seamless intelligent environments, designed to adapt to the presence of people, understand their needs and intentions, and free them from manual control of their surroundings. From 1999 onward, this vision was positioned to take the future of European electronics and materials science forward. It projected viable infrastructures for interoperable networks and miniaturized devices, for which intelligence could be designed (Aarts et al, 2001). However, by 2010 it became clear that the *intelligence* in ambient intelligence research had not matured to enable incremental studies—a vital component for continuity and consistency in technical development:

> We would expect to be witnessing the emergence of enduring principles and of a growing body of research findings and solved challenges. Instead, much of the research effort still seems to be devoted to the creation, very often from scratch, of technologies and systems for enabling the scenarios described in the AmI vision (José et al, 2010: 1482).

José et al. (2010) note that the advisory group to the European Commission (ISTAG) called the AmI vision a *starting point* in 2003—that 'future scenario building and iterations of the vision should treat AmI as an 'imagined concept'' (ISTAG, 2003). Scenarios should not be seen as a set of specified requirements but a means of promoting reflection and debate. This starting point however, is first formulated within Philips Research. It emerges in conjunction with a quest for new ideas to advance electronics research, engineering and materials science at the intersections of a consumer marketplace. It emerges in conjunction with an apparatus of European research investment and subsidy (also ISTAG, 1999). It motivated, inspired, and quickly became the key unifying element in establishing a normative AmI research agenda that formed the basis for impact assessments (e.g. ISTAG, 2002b; ISTAG, 2006) and ethical, legal and social reviews (e.g. Wright et al, 2008).

The original AmI scenarios are in fact the first step in specifying requirements on how to realize ambient intelligence, regardless of efforts to debate and reflect on the kinds of futures the scenarios depict. Key-enabling technologies are identified and a near-future breakthrough in artificial reasoning is anticipated—a promise to revolutionize computational capabilities in assisting humans in their everyday affairs. Expectations of adaptive, proactive and socially embedded applications are encouraged by visionaries and research leaders within Philips. Later, the AmI vision is radically modified by the same agents to account for research outcomes, emerging critiques, reservations and new ideas of designing for *synergetic prosperity*.

Innovation practices are demanding of communication and interactivity between disciplines, organizations and markets (e.g. Borup et al, 2006; Brown and Michael, 2003; Brown et al, 2000). Envisioning work inspires and cultivates expectations of what can be achieved. It displaces complexity and conceals the uncertainties. It is therefore of particular interest how envisioning and accounting for AmI developments exemplifies unique efforts to capture complexity and uncertainty, especially, relating to the subtleties of daily human living for which AmI designs are envisioned. Reasoning, emotion and sociality in everyday experience have been systematically investigated and the very concept of *intelligence* remains loosely defined to the effect that expectations have not become too path-dependent or irreversibly locked in. In fact, the vision of AmI has been deliberately complicated over time in attempts to get at the heart of how to design the *intelligence* in Ambient Intelligence.

Visions, promises and expectations

In keeping with Foucault's notion of historical a priori (Foucault, 2002[1969]), *conditions of* *possibility* refer to the mutually constitutive relationship between discourse and technology. Drawing on Kant's original formulation, they safeguard from stories of simple causation. Conditions of possibility specify the conceptual and phenomenological landscape wherein combinations of elements give rise to appearances, in this case, the phenomena of AmI. Conditions of possibility also refer to characterizations of technology, described by Heidegger as novel modes of disclosing the world (Heidegger, 1977). New domains of the world are summoned to give themselves up to human control. Phenomena become subservient reserves for future world-making and radical human-world reconfigurations, however, the consequences might not be well understood (see e.g. Araya, 1995). But these conceptions assume that new developments are focused on well-known technical problem domains rather than speculative future domains for which reliable engineering principles are still missing. As José et al. (2010) remind us, no AmI phenomena, as originally conceived, are actually *in the world*. They only exist in AmI visions of the future.

Promising and postponing *intelligence* in AmI development, draws attention to studies in the Sociology of Expectations. Promises and expectations have always been associated with new innovations but, as Borup et al. point out,

> they are not historically constant and it may even be argued that hyperbolic expectations of future promise and potential have become more significant or intense in late and advanced industrial modernity (Borup et al, 2006: 286).

The expectations Borup et al. refer to, are rhetorical in the sense that they persuade others that the imagined futures are desirable and can be realized (see also e.g. Brown et al, 2000). Expectations of future promise and potential are enacted and performed in establishing mutually binding obligations and agendas. They are generative in instigating concrete plans for strategic innovation agendas. '[T]hey guide activities, provide structure and legitimation, attract interest and foster investment' (Borup et al, 2006: 285-6). The complexity of these practices has also called for caution and responsible accounting for failure (Brown and Michael, 2003), or as Borup et al. put it, to account for visions that continually under-perform (Borup et al, 2006: 295). But narratives of the future turn on hopes rather than truths. The rhetorical, anticipatory discourse they are embedded in struggles to secure coherence and continuity, and failure to deliver creates a temporal tension. However, the desired future is not abandoned. It is postponed while undegoing modifications. In other words, what counts as a successful or failed promise is less about truth or falseness, strictly speaking, than negotiating the credibility of ongoing envisioning work and managing disappointment (Tutton, 2011; also Sunder Rajan, 2006).

Expectation studies are largely confined to economic discourse and latest advances in the biological sciences—in genomics, nano- and medical technologies. Much less attention is devoted to innovation networks that seek to maintain or resurrect expectations of human-like intelligence. Dynamics of promise, expectations and disappointment will be found throughout the history of artificial reasoning and human-computer communication research. Firstly, the technical problem domains have repeatedly come under direct scrutiny by philosophers and anthropologists, for example, why disembodied intelligence is not achievable (Dreyfus, 1992), why the contingencies in ordinary situated action are, by necessity, inaccessible to computational functions (e.g., Suchman, 2007), and why completely seamless infrastructures are a myth that cannot be realized (e.g., Bell and Dourish, 2007). Secondly, much of the envisioning work relies on socio-cultural depictions of everyday occupational, private and public affairs—visions which then are wide open to critique for being culturally impoverished and under-socialized (see e.g. Barbrook, 2007; also Forsythe, 2001). Thirdly, some of the challenges come from within the scientific and technological communities. Recent years have seen a complete rethinking of earlier envisioning work and a growing interest in everyday experience, emotion, embodiment and situatedness as research and design topics (see Aarts and de Ruyter, 2009; Aarts and Grotenhuis, 2009; Westerink et al, 2008; Boehner et al, 2007; Hvannberg, 2006; Sengers and Gaver, 2006).

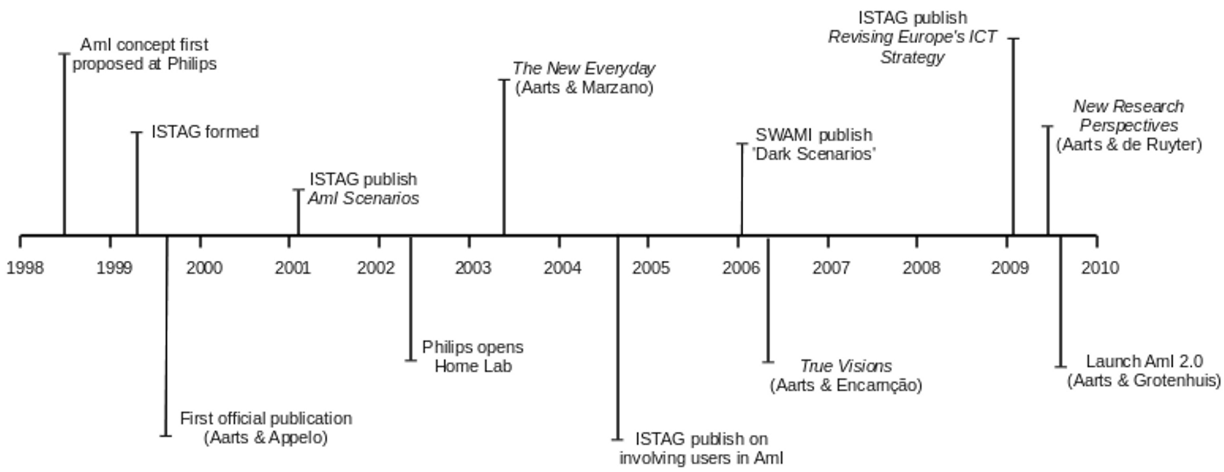

Figure 1: A timeline of key events and publications on Ambient Intelligence

The case of AmI

Figure 1 is a timeline of events and publications we use heuristically to create a sense of the temporal ordering of the AmI narrative. We have divided this ordering into four main sections in which we focus on Philips' contributions to a continuous imagining of utopian lifestyles and socio-technical arrangements. The work of Philips Research is a particularly well-illustrated example of what Pollock and Williams call a *promissory organization* (Pollock and Williams, 2010), and we shall clarify the dynamics of expectations, cultivated within Philips and beyond by the leading *promissory agents*. But the key task is to understand how the AmI vision contributes to the evolution of its own conditions that make the appearance of technologies and applications *seemingly* possible with necessary recourse to what is *actually* possible.

In the following sections we recover the conditions for AmI to appear as an innovation narrative in the first place—a novel mode of disclosing the world through technical thinking. We explain how expectations of AmI are rhetorically formulated, enacted and performed. Thereafter, we consider the commitment by visionaries and research leaders to an extraordinary range of practices and resources which significantly complicate this innovation narrative and call for perpetual accounting for contingencies. We explore the quest for improved understanding of the social, embodied and emotional in human experience, and continuous efforts to align AmI lifeworlds with the lived experiences of prospective users. We follow the involvement of a growing number of disciplines as they generate and accommodate substantial critiques (Aarts and Marzano, 2003), and we examine the iterative work of rebuilding expectations and re-imagining the role that ICTs will have in shaping the everyday of the future, in particular, what *intelligence* can possibly stand for (Aarts and Grotenhuis, 2009; Aarts and de Ruyter, 2009).

Locating origins

Locating origins is often a misleading way of showing that something significant has an essence or a stable identity. But if we had to specify a birth date of ambient intelligence, we can pinpoint a single co-authored presentation given at Philips in June 1998, titled: *From Devices to 'Ambient Intelligence': The Transformation of Consumer Electronics* (Zelkha and Epstein, 1998). In the official version of the story told by Emile Aarts, the Chief Science Officer at Philips, the concept was first 'proposed in 1998 in a series of workshops that were organized within Philips, and that were commissioned by the Board of the Management' (Aarts, 2003: 2). We can infer from this remark that the birth of AmI belongs to Philips and, after 1998, the concept of *Ambient*

Intelligence is primarily associated with the company's vision of the future of consumer electronics.

It is rarely the case however, that *great ideas* appear from nowhere. Establishing the continuity of an older idea shows that the invention has a precedence or respectable pedigree; that it forms part of a successive chain of ideas, originating with a great inventor. This method of accounting for the past to give respectability to something in the present (or to index its promising future) is evident in how we are routinely told that AmI builds on a previous set of ideas about the future of computing:

> The first official publication that mentions the notion “Ambient Intelligence” appeared in a Dutch IT journal (Aarts and Appelo, 1999) and emphasized the importance of the early work of the late Mark Weiser, who had been working for more than ten years already on a new concept for mobile computing which he called *ubiquitous computing* (Weiser, 1991). From a technological point of view this concept has been very influential and it can be viewed as the starting point for several new developments, including IBM’s pervasive computing and Philips’ Ambient Intelligence (Aarts, 2003: 3).

The much cited article by Weiser, *The Computer for the 21st Century*, proposes that computing will disappear into wired and wireless networks (via infrared and radio frequency), operated by mobile pocket-size and page-size machines known as ‘pads’ (Weiser, 1991). Also, IBM’s concept of pervasiveness refers to massively distributed networks, interoperability and scalability. Drawing on these objectives, the AmI vision was originally one of maximizing the potential of consumer electronics, telecommunications, materials science and computing, to support ‘people and objects to interact with their environment in a seamless, trustworthy, and natural manner’ (Aarts and de Ruyter, 2009). But, the vision proposed to go one step further. AmI visionaries and research leaders were seeking to improve and enrich people’s lives with a *laid-back* rather than a *lean-forward* mode of human-computer communication (Zelkha and Epstein, 1998). Computing should ‘move from an *explicit, instructional* model to an *implicit, anticipatory one*’ with context aware, personalized, adaptive and anticipatory intelligence, embedded in the places we live, work, relax, travel, shop and learn (e.g. Philips Research Online, Website).

Operalizing the vision

This vision became operational very early on. Aarts and Encarnação (2006a) take the example of a collaboration which began in 1999 with the MIT computer science and artificial intelligence laboratories to claim that: 'the AmI vision has also been used to establish new and promising collaborations with other strong players in the field' (Aarts and Encarnação, 2006: 6). The vision performed well in strategic planning of research and development across Europe. Among the questions asked at the time was where the European electronics industry and academe stood in relation to the rest of the world, and how to ensure its global competitiveness (see figure 2; also ISTAG, 2000). The AmI vision was adopted by the Information Society Technologies Advisory Group (ISTAG) to develop a strategic research agenda:

> The 'vision' which emerged, and which bound together the three main strategic issues was: 'Start creating the ambient intelligence landscape (for delivery of services and applications) in Europe using test-beds and open source software, develop user-friendliness, and develop and converge the networking infrastructure in Europe to world class' (ISTAG, 1999).

ISTAG advised the European Commission in 2001 to use the AmI vision for the launch of the 6th Framework Programme in IST, and thereby positioned AmI as an *initiative*, open to contributions from academic and industrial players to develop the key-enabling technologies (see figure 2).

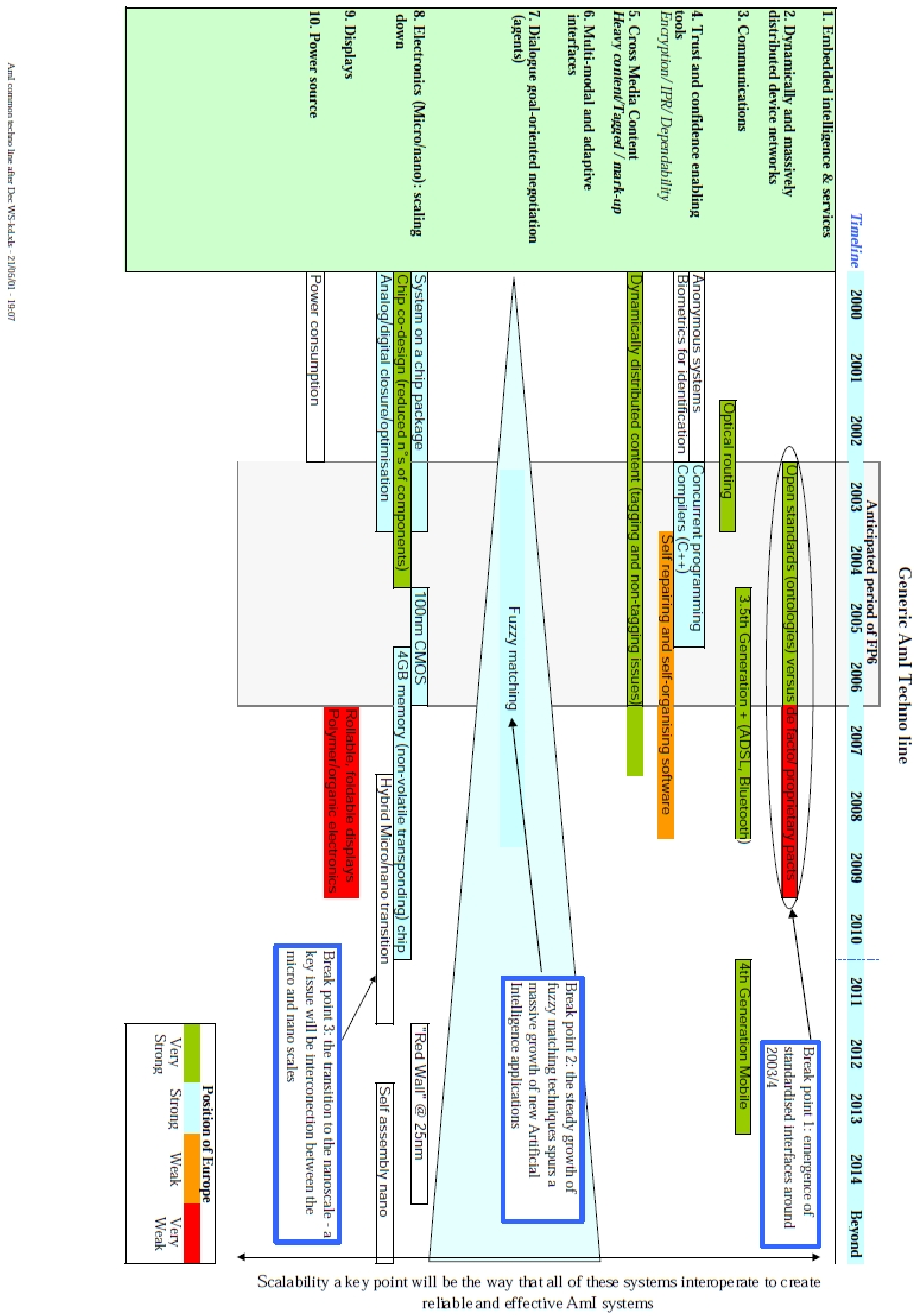

Figure 2: Overview of the status of generic AmI technologies in Europe. Separate charts were also developed on the basis of four different domains of future applications (The figure is borrowed from ISTAG, 2001).

To sum up, locating the origins of AmI provides the basis for building a promissory narrative by showing that earlier ideas of ubiquitous and pervasive computing are solid foundations for a vision that will mature over time. The conditions of AmI's appearance are related to how well a vision serves to describe what the future of electronics and materials science could look like and to describe what is needed to get there. It allows AmI visionaries and research leaders to disclose possible and seemingly desirable futures enabled with AmI applications. However, the appearance of AmI is not simply the building of one idea on another. It is a cultivation of capacities to act that promises to realize the vision. *Ambient Intelligence* became a watchword for developing industry collaborations, for marshaling European investment and establishing alignment with a broader narrative of Europe's ICT future (ISTAG, 2002a). It was immediately operational in the work of ISTAG. Key-enabling technologies were identified, a strategic agenda organized, and subsidiary budget allocated to European electronics research, materials science and engineering to the amount of €3.7 billion over four years.

Building expectations

Building expectations is the work of imagining AmI worlds, of clarifying the broader mission and communicating what the key-enabling technologies are. Two rhetorical strategies are regularly used to build expectations about AmI: *controlling inferences* and *scenario building*.

Controlling inferences

One way in which the AmI vision is made desirable is by controlling the meanings of the terms *ambient* and *intelligence*. Commentators carefully assign concepts and descriptions that imply a balance between ubiquity, invisibility and agency:

> Ambient intelligence can be characterized by the following basic elements: ubiquity, transparency, and intelligence. Ubiquity refers to a situation in which we are surrounded by a multitude of interconnected embedded systems.
>
> Transparency indicates that the surrounding systems are invisible and moved into the background of our surroundings. Intelligence refers to the fact that the digital surroundings exhibit specific forms of intelligence, i.e., it should be able to recognize the people that live in it, adapt themselves to them, learn from their behavior, and possibly show emotion (Philips Research Online).
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> The notion *ambience* in Ambient Intelligence refers to the environment and reflects the need for an embedding of technology in a way that it becomes unobtrusively integrated into everyday objects. The notion *intelligence* reflects that the digital surroundings exhibit specific forms of social interaction, i.e., the environments should be able to recognize the people that live in it, adapt themselves to them, learn from their behaviour, and possibly act upon their behalf (Aarts and Encarnação, 2006a: 2 [original emphasis]).

In addition to promising elsewhere that AmI will improve, support and enrich people's lives, a great deal of work is invested in controlling inferences about the user's relationship with digital surroundings and embedded devices. The warranting of simplicity, seamless interactivity and dependability, and constant references to simple and unobtrusive design, are ways of countering concerns that AmI applications are potentially unreliable, complicated and intrusive. Technology should be *key* but always in the background whereas users are depicted in the foreground, supported and assisted by proactive intelligence.

While the early reports of ISTAG describe *user-centric* or *people-centered* designs, we also learn that artificial reasoning will possibly do things proactively *for people* and *on their behalf*. Expectations of intelligence were built around anticipated near-future achievements in artificial reasoning, soft computing, cognitive science and related research in order to attract expertise from these communities (see figure 2, brake point 2 on fuzzy matching; also Fortuna et al, 2001, Denning, 2002; Loia, 2002). In other words, the idea of proactive machine intelligence is stressed as essential to ensure the user-friendliness of strongly personalized applications that people can trust (e.g., ISTAG, 1999 report on orientations and beyond).

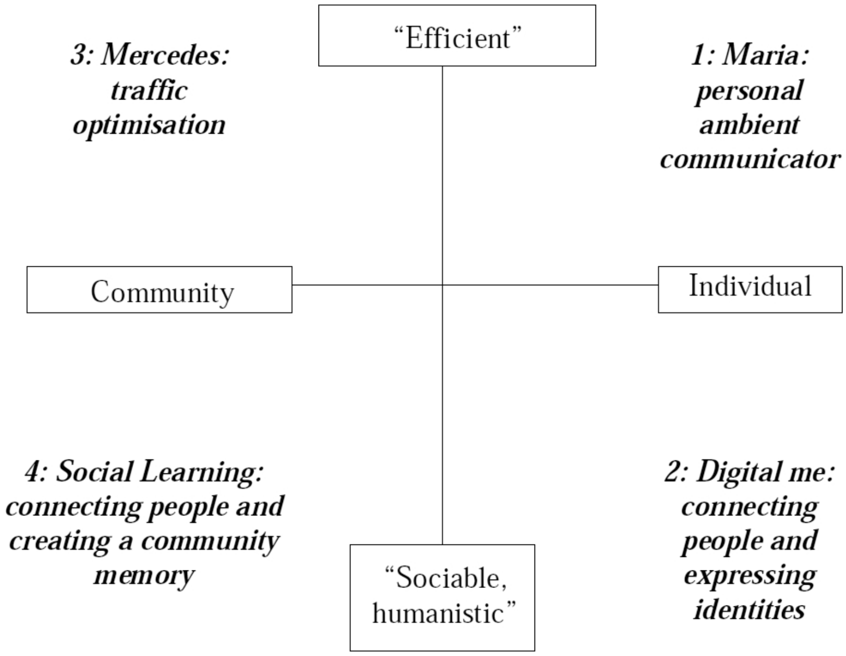

Figure 3: A schema for the four scenarios, first presented by ISTAG in 2000, shows the interconnections between four targets. 'The main structuring *differentials* between the scenarios are: ***efficiency*** versus ***sociability/humanistic*** criteria as the demand driver, and ***community*** versus ***individual*** as the type of user driver' (ISTAG, 2000).

Scenario-building

ISTAG commissioned a workgroup to develop scenarios and identify the components needed to build the enabling infrastructure while meeting the requirement that this work should be oriented to business models and market potential (see ISTAG, 2001). Scenarios are used in computing to describe imagined or foreseeable interactions between users and systems. If they are construed as specific user cases, they further break down system requirements into functions, goals, actions and reactions. But, in all cases, they inevitably involve characters going about some business and, therefore, they represent visions of lifeworlds inhabited by those who are imagined as potential users. In other words, scenarios offer a way of constructing highly descriptive hypothetical illustrations to solve technical problems as well as to align technologies with potential markets, reach out to investors, and flesh out the expectations of prospective users.

Scenarios are prospective and promissory devices par excellence, and the role they have played in shaping the field of AmI developments cannot be underestimated. For example, the ISTAG scenarios promise optimized transport and work productivity, more efficient social life and family cohesion, improved health monitoring/management, safety and security, and easier access to information and entertainment. They include spaces of occupation, habitation and activity (home, office, school, hotel, car, conference center) as well as so-called non-spaces or transits (terminals, roads, etc.). For example, scenario 1: ‘Maria: personal ambient communicator’ (see figure 3), describes a professional woman with family obligations traveling to a conference in a remote country. We learn how AmI landscapes and applications make her busy life easier, e.g., how immigration procedures are automatically managed, how city traffic is efficiently navigated and how staying in touch with family members is made easy from remote. The following is an abbreviated version of the full scenario, ‘Maria the Road Warrior’ (ISTAG, 2001):

> Maria passes through the arrivals hall of an airport in a Far Eastern country […] Her computing system for this trip is reduced to one highly personalised communications device, her ‘P–Com’ that she wears on her wrist […] [H]er visa for the trip was self-arranged and she is able to stroll through immigration without stopping because her P-Comm is dealing with the ID checks as she walks.
> A rented car has been reserved for her and is waiting in an earmarked bay. The car opens as she approaches. It starts at the press of a button […] She still has to drive the car but she is supported in her journey downtown to the conference centre-hotel by the traffic guidance system […] Maria has priority access rights into the central cordon because she has a reservation in the car park of the hotel […] at a premium price […] embedded in a deal negotiated between her personal agent and the transaction agents of the car-rental and hotel chains. […] In the car Maria’s teenage daughter comes through on the audio system […]
>
> Maria is directed to a parking slot in the underground garage […] She is met in the garage by the porter – the first contact with a real human in our story so far! He helps her with her luggage to her room. Her room adopts her ‘personality’ as she enters. The room temperature, default lighting and a range of video and music choices are displayed on the video wall […] Then she calls up her daughter on the video wall, while talking she uses a traditional remote control system to browse through a set of webcast local news bulletins from back home that her daughter tells her about. They watch them together.
>
> Later on she ‘*localises*’ her presentation with the help of an agent that is specialised in advising on

> local preferences (colour schemes, the use of language). She stores the presentation on the secure server at headquarters back in Europe. In the hotel's seminar room where the sales pitch is taking place, she will be able to call down an encrypted version of the presentation […]

The first thing we notice is how everything works seamlessly. Insofar as the infrastructure and applications are envisioned, the ISTAG reports (from 1999-2002) repeatedly mention *trust*, *dependability* and *security*. Identification technologies need to be dependable and secure, network and data management infrastructures reliable, and people convinced that the applications will *do for them* what is intended in AmI designs: '[S]he is able to stroll through immigration without stopping because her P-Comm is dealing with the ID checks as she walks', '[t]he car opens as she approaches', 'a deal [is] negotiated between her personal agent and the transaction agents of the car-rental and hotel chains', '[h]er room adopts her 'personality' as she enters', 'an agent […] is specialized in advising on local preferences'. These are examples of embedded proactive intelligence and it is noteworthy that Maria's 'first contact with a real human' is only after she is in the hotel garage—the exclamation signaling a triumph of intelligence design.

As this scenario illustrates, there is no indication of conflict between the proactive actions of AmI applications and what Maria wants or needs to do. The characters in the other three scenarios are worth considering in this respect. They always know what they need or what they want to do. The home is always functional, a sanctuary for comfort, entertainment and learning, and the family is an idealized functional unit. Everyone is a professional, a student or retired, leading informed and active lifestyles with disposable incomes. At the time, these stereotyped and idealized vignettes had not yet been tried and tested against knowledge of user experiences (de Ruyter, 2003; Hartson, 2003; ISTAG, 2004). To bridge the gap between vision and reality, a network of laboratories emerged across Europe in the early 2000s (see Hvannberg, 2006). In May 2002, a so-called Homelab became the first in a number of Experience Laboratories at Philips, designed to explore how people interact with AmI prototypes in mundane settings, and to come to grips with what users actually want.

Accounting for contingencies

A striking feature of the AmI narrative is continuous modulation of promises. But we also identify highly reflexive practices of anticipating possibilities, limitations and dangers, with which the future horizon is adjusted. One is the unique strategy of deliberately complicating the expectations by aggregating disciplines to carefully explore the subtleties of ordinary reasoning, communication and interaction in everyday situations. Another strategy is the world-making that situates AmI in a social economy and a culture undergoing radical changes. The third is to earnestly engage in the contemplation of futures to be avoided.

Complicating expectations

Deliberate complication is an innovation practice, subjecting AmI developments to an ever-growing number of disciplines and methodological approaches which require continuous experimentation, monitoring and reporting. For example, a diversity of views on design methods and AmI products is illustrated in the 2003 publication *The New Everyday: Views of Ambient Intelligence* (Aarts and Marzano, 2003). Containing 100 contributors from engineering, design, sociology, psychology, linguistics, business, computer science, and more, this edited collection explores a broad range of empirically-based design issues such as integrating electronics into clothing and textiles, developing speech recognition and context-aware sensors, and designing enhanced mobility and predictive capabilities. In particular, the inclusion of psychology and the humanities reveals a concerted effort to differentiate experiences in terms of memory, space, time and movement, and develop a shared understanding of human interaction and communication. In other words, multidisciplinary collaborations investigate the stability and utility of imagination, expertise and synergy between different knowledge regimes. Disciplinary synergies however, further complicate the AmI vision by identifying limitations and complications, as well as new possibilities.

The Experience Laboratories at Philips in Eindhoven have recreated various real-life conditions to experiment with AmI prototypes in real time. Modeling a kind of Big Brother environment, concealed digital cameras monitor mundane situations, usage patterns and unforeseen events arising from naturally occurring interactions between people and prototypes (figure 4). Simulation (e.g., recreating the home environment) and duration (conducting observations over long periods) are methods of obtaining ecological validity, i.e., ensuring that research data actually reflect user experiences. It provides a background against which behavioral events and usage patterns can be intelligently filtered, as researchers put it, where contingencies in product function can be isolated and mis-alignments in user-technology interactions identified.

Figure 4: The Philips HomeLab observation room (from the Philips website)

Continuous monitoring introduces its own set of complications. Massive data sets require a multidisciplinary team of sociologists, anthropologists, cognitive psychologists, designers, engineers, etc., 'to represent realistically the complexities and subtleties of daily human living'

(Hartson, 2003). These collaborations have been essential to exploring the multi-dimensionality of user experiences and incorporating user-experiences into product design. They also allow research leaders to make strong assertions about people's expectations:

> Studies into the meaning of the home of the future have revealed that people want this home of the future to be like the home of today. Based on in-depth interviews we discovered that people fear scenarios of the future in which technology would interfere with their daily life in the home of the future. In fact, people expect technology to become more supportive in the future [...] The biggest challenge for future technology is thus to be not only physically embedded but also to be interwoven into the social context of the home of the future (de Ruyter, 2003: 6).

Visiting the Laboratories

When we visited the Experience Laboratories, we had the opportunity to interact with an ambient shop window in a so-called ShopLab, and discuss with lab researchers their observations and thoughts on the development of prototypes. As figure 5 illustrates, a woman who is window-shopping sees the shoes she is gazing at appear in a projection on the window. A sensor detects her presence and tracks her eye movements, triggering the relevant interactive media display on the window pane with touch-screen access to the product line. We asked if people were comfortable with sensors intercepting their private gaze and knowing that what they are looking at is displayed for others to see. A lab researcher told us that the window projection used to be larger and people reported discomfort with its size. We discussed the types of shops and scenarios where this kind of interaction might be problematic, for example, when looking through the window of a lingerie shop. It is a common misconception that a correlation is given between one's preference and what one looks at. We also discussed the possibility of whether software could detect gender or suggest accessories based on what a person is wearing. Lab researchers were experimenting with underground sensors to detect the weight distribution of a standing person. The sensors could detect high and low heels, although researchers admitted it was not a fool-proof indicator of gender. They also admitted that smart cameras might not detect the difference between a pregnant woman and a man with a large belly. Thus, we might not expect a vendor of maternity clothes to express a keen interest.

Figure 5: From the ShopLab: the interactive shop window (from the Philips website)

Another question raised in our discussions was whether the research design was in some way mistaken about ordinary window-shopping situations even if prototypes work satisfactorily in laboratory settings. As one lab researcher noted, people are often shopping in pairs and more than one person can be looking through a shop window at any given time. Eye-tracking devices will have no way of judging whose eyes to track, especially in the context of ongoing interactions between those who stand, gaze, point, gesture and talk outside the window. In other words, attempts to design proactive intelligence to enhance the window-shopping experience could easily result in irrelevant and potentially awkward device interference.

Here, the AmI vision is complicated by its key emphasis on designing *intelligence* to appeal to everyday experience. A number of contributions to a 2008 publication in the Philips Research Book Series (Westerink et al, 2008), agree that it remains unclear which aspects of human-device interaction result in affective experience or which factors are part of the user-experience more generally, how they relate and how they can be accessed for design purposes. The general problem is how to bring social experience factors and connectedness into an explanatory model to optimize methods for experience design and analysis. Models and theories are primarily descriptive. They provide only general rather than concrete technical specifications in product development, and researchers are often making use of *ad hoc* interpretations. But the problem in our example is not only that window-shopping can be a complicated social activity or that uncertainties surround methods of *designing for* shared experiences. It also turns on the question of whether we actually want so-called smart applications to intercept us proactively, to act on our behalf or in our best interest. As Marzano suggests:

> We should be careful not to just replace that old mantra [more is better] with a new one of ‘smarter is better’. Perhaps we shall discover that we don’t want ‘everything intelligent’ or ‘everything done for us’. It may be ‘good for us’ to struggle to do certain things. We may not want a toaster that talks, or a juicer with e-mail access. We have a duty to take out a metaphorical insurance policy for future generations. Ambient Intelligence could lead to great opportunities, but it will need to be guided (Marzano, 2003: 8 [original emphasis]).

World-making

Accounting for contingencies is a rhetorical strategy of depicting worlds in which AmI visions and technologies seek alignment with socio-economic and cultural imaginaries, and respond to global changes. In the early 2000s, world-making accounts begin to locate the AmI narrative within a history of changing cultural and economic frameworks. In the ‘mosaic society’, for instance, we are told that advanced individualization creates ‘‘mosaic’ lives, made up of a kaleidoscope of simultaneous or sequential relationships, careers or lifestyles’ (Green, 2003: 23). This is a world in which the intolerable rise of complex information and choice can be reduced significantly with intelligent applications: ‘Ambient Intelligence can help simplify and personalize our lives as we look for ways to cope with complex situations and juggle with our multiple lives, options and commitments’ (p.23). But in Aarts and Marzano’s edited collection of 2003, we also see how multidisciplinary reflection contradicts the plausibility of this depiction. In the following account, for instance, sociologists are quite dismissive of the foundational aims and assumptions of a world, populated with AmI applications:

> [W]hile some features of Ambient Technology are based upon naïve ideas about human psychology and social life, others are superfluous: they are either taken care of by present technological systems … or so far out (like projecting a sunset on one’s windowpane) that only the very few who don’t know what to do with their money will care to buy it. Geared as it seems to be to the affluent, much of Ambient Intelligence looks like superfluous ‘gadgets for the rich’ (van Lente and Homburg, 2003: 30-1).

The triviality of AmI applications and their appeal to techno-affluent consumers is a strong indictment against the original vision. Incorporating such views demonstrates not only flexibility and tolerance, but shows how criticisms are absorbed and neutralized. The inclusion of competing disciplinary perspectives that challenge the utility of applications and their implicit assumptions about users indicate the ways in which AmI visionaries and research leaders can anticipate challenges and develop a more robust vision.

Over the years, these world-making accounts have begun to describe major shifts in social and economic value, and significant change in identity and experience (e.g., Green, 2007). World-making performs at least two kinds of functions here. It *constitutes* new worlds as part of a broader historical narrative of change and it *justifies* AmI environments and applications as solutions to these proposed worlds:

> As technology merges into our walls, floors and clothes, then we no longer 'consume' technology, but live with it side-by-side as it supports and facilitates our daily living, an invisible helper at the ready. Through this more intimate co-existence our identity becomes less about needs ('what do I want?') and more about activity and experience ('how can I best take advantage of what I want to do in the way I want to do it?') […] Philips' vision of ambient intelligence is about this relational co-existence, and by changing the paradigm between people and technology it has the potential to take us beyond consumption as classically understood. In the context economy, value is generated less through the selling and buying of goods and more through an ecosystem of information, services, experiences and solutions (Green, 2007: 14).

In this document titled: *Democratizing the Future*, the vision of AmI is positioned as a 'new interaction paradigm' between people and technology. It aligns with notions of sustainable economics and ecology, i.e., to 'take us beyond consumption' and traditional theories of value, toward a new 'ecosystem of information, services, experiences and solutions' within a context and experience economy. According to Green, whose background is in history and politics, AmI applications are facilitators of societal responsibility and sustainable development. They are no longer about consuming things. They are about communicating, sharing and enriching lives with the help of smart applications.

Futures to avoid

Identifying futures to avoid, for example, technology that interferes and frightens people, has become integral to accounting for contingencies, and accounting for AmI visions more generally. Research external to the AmI community has shaped the narrative significantly in this respect. In 2005 the European Commission launched SWAMI (Safeguards in a World of Ambient Intelligence), which mounted a robust critique of the original ISTAG scenarios. Drawing on legal, ethical and innovation studies, the SWAMI team developed a set of *dark scenarios* to illustrate the extent to which an AmI information system challenges privacy, identity and security. They illustrate what happens when smart applications go wrong; when identity-based data is misused or incompletely processed; when people are excluded from services due to lack of interoperability, inadequate profiling and data mismatches. The report also dramatizes the loss of privacy and equality when citizens/consumers are subject to surveillance and sophisticated personal and activity profiling; when access to technology becomes unequal; and when the expansion of information services results in greater risk of spamming, disclosure of private data and malicious attacks (Wright et al, 2008).

The foreword of the 2008 publication of SWAMI is written by Emile Aarts. He begins with an anecdote of presenting one of his AmI lectures, proceeding with his ‘normal positive and technology-driven motivation for the need to have ambient intelligence, but I could read from the faces of the audience that they were not amused by my argumentation’. One of the first remarks from the audience was ‘a nice person from Austria who exclaimed that my talk was both ingenious and ridiculous’ (Aarts, 2008: v). After describing his experience of leaving the conference chastened, he gives the following account:

> It is my conviction that the work this group [SWAMI] had been doing is of utmost importance. The development of ambient intelligence is going on for almost 10 years now and most of the time we have been emphasizing the technological potential of this novel and disruptive approach. We have also been largely building on the belief that user insight and user-centric design approaches should be used to come up with solutions that really matter to people, but we hardly paid attention to questions related to such important matters as trust, security, and legal aspects, nor to speak about the more ethical issues such as alienation, digital divide, and social responsibility as raised and discussed by the SWAMI community [...] I would like to thank the SWAMI people for giving me the opportunity to have one of the most compelling learning experiences in my professional life (Aarts, 2008: vi).

This reflexive display of accountability is framed as a ‘learning experience’. The absence of excuses and justifications are indicative of a flexible and apologetic orientation. Aarts describes how in the past an over-emphasis on technological potential was kept in check by adopting ‘user-centric designs […] that really matter to people’, thereby implying *some* level of responsibility.

But he freely admits that ‘the more ethical issues such as alienation, digital divide, and social responsibility’ were neglected.

Accommodating diversity of challenges is a way of developing the AmI vision, while maintaining alignments with significant stakeholders and markets. In this sense, promising is not simply a gesture of making excessive claims about prospective worlds and futures. It is an iterative practice that guides and motivates the evolution of the AmI narrative that constitutes and is constituted by multidisciplinary activities. Strategies of complicating the vision, of transformational world-making and highlighting futures to avoid, are manifested in what we observe to be *perpetual accounting for contingency*. Experimental outcomes foreground the elusiveness of *intelligence* in AmI designs and, more generally, the elusiveness of what people actually want. But these outcomes as well as claims and disappointments about AmI futures are absorbed over time into the dynamics of expectations which then are rebuilt around new conceptions, new conditions of possibility and capacities to act.

Rebuilding expectations

Although *rebuilding expectations* is an iterative activity, it has special relevance as we approach more recent events on the AmI timeline. Both the SWAMI critique and the economic downturn had an impact on the AmI narrative as did the revising of Europe’s ICT strategy (ISTAG, 2009). New innovations on the market have demonstrated what machine intelligence can accomplish without being *proactive* or *socially intelligent* strictly speaking. The iPhone (and smart phones more generally) can do more or less what a person like Maria needs to have at hand. Social networking keeps people connected, and interoperable networked applications enable shared access to information, interactive media, and more. In other words, pervasive and ubiquitous computing is *already here* (see Bell and Dourish, 2007 on this issue).

By mid 2009, we see a tidal change in emphasis on responsibility and sustainability. Doubts about the viability of the original scenarios in relation to global change led to a re-visioning of AmI:

> One may, however, question whether the scenarios still reflect the way people want to live by 2010. In our opinion this is indeed not the case; there are strong indications that people have shifted their desires profoundly. This is partly due to the current financial crisis and partly due to the growing awareness that a sustainable development of our society calls for an approach different from the technology push of the past decades […] After a decade of developing and experimenting with the AmI vision, we need a new paradigm (Aarts and Grotenhuis, 2009: 6).

Aarts and Grotenhuis distance themselves from the early scenarios as no longer reflecting what people want. Financial crisis and a shift towards sustainable development of our societies are mitigating factors which call for further envisioning work. A discourse of sustainability, with its benign inferences of ethical and ecological responsibility, provides the basis for rebuilding the AmI vision around a conception of collective prosperity:

> *Synergetic Prosperity* is about the balance between these elements [People, Planet, and Profit]. Only in the presence of a balanced situation, Ambient Intelligence can truly contribute, using its inherent properties such as its dematerialized embedding and its ability to tailor towards people's needs (Aarts and Grotenhuis, 2009: 6).

Aarts and Grotenhuis employ the concept of synergetic satisfiers to distinguish transcendental *needs* from *satisfiers*, which are entirely immanent to context. This coincides with the more recent perception that technology should no longer be oriented to patterns of consuming things. Rather, it should facilitate a new ecosystem and economy.

Figure 6: Proof of concept. An AmI experience for children in a radiology suite (from the Philips website).

This new narrative seeks context-specific solutions which satisfy multiple needs. What is called AmI 2.0 retains the original aims of embeddedness, ubiquity and intelligence, but 'Synergetic Prosperity refers to the development and application of eco-affluent innovations that allow all people to flourish' (Aarts and Grotenhuis, 2009: 8). In this reconstructed version of AmI, we see a concerted attempt to balance expectations through a vision of sustainable health and well-being, and the equitable distribution of wealth and education. We also see a focus on specific product examples where novel experience has indeed been successfully put to work in concrete settings. Here, the promissory register is restrained as it accounts for context-specific applications that prove the existence of synergetic satisfiers.

For example, the photo in figure 6 is a snapshot, representing a radiology suite supporting an AmI experience. CT scans require that the subject stays completely still inside the scanning apparatus. This is particularly difficult for children who are often impatient, fidgety or anxious in these circumstances. Executing a scan can take hours, placing considerable strain on parents, children, health professionals and health service resources more generally. Philips designed an AmI experience, first installed at a children hospital in Chicago 2005—an animation and an interactive game that children can control in preparation of a scan. Proof of concept is realized. If scanning no longer takes hours, children enjoy the experience, parents are calmer, health professionals and providers are relieved, then everyone is satisfied.

The reconstruction of the original AmI vision lies in its dispense with product scenarios based on affluent consumption. Achieving synergetic prosperity establishes empirically that AmI 2.0 applications can deliver experiences that are profitable *and* socially responsible.[1] This shift from transcendental imagination to immanent application has significantly scaled down the expectations of seamless worlds in which these applications are embedded. The new applications are modest, almost trivial, in the sense that they are a far cry from the original vision of large seamless infrastructures accommodating the ubiquity of particular forms of artificial reasoning.

New research perspectives

The introduction of AmI 2.0 coincides with a new perspective on social intelligence and embeddedness, and it represents a major shift in how the intelligence in future applications is described (Aarts and de Ruyter, 2009). Earlier we argued that inferences about ambient intelligence are carefully controlled, but the concept of intelligence remains elusive. AmI research and development to-date rests on the successes of previous and related visions of ubiquity, mobility and pervasiveness, all of which are impressively achieved. But the promise of intelligence has always been moderated. AmI applications will *possibly* show emotion, *should* be able to recognize the people that live in [AmI environments], and *possibly* act upon their behalf. In the Philips company literature, we also see warnings against a mantra that 'smarter is better' (Marzano, 2003), even an explicit rejection of the idea that intelligence means that:

> products should take decisions for us, like in these futuristic examples where people get home and coffee machines start preparing cappuccino. Users should keep control over their environment.

1 Emile Arts has also taken the example of a handy and self-sustainable light-source application that helps Africans or Chinese read, write, do homework, etc., at night in regions where electricity is in very short supply (Keynote Lecture at the International conference, "ICT that makes the difference" in Brussels, 23 Nov 2009; see also Aarts and Grotenhuis, 2009: 8-9).

(Anton Andrews, Philips Design quoted in Ashruf, 2005).

There has also been ambiguity about the relationship between what precisely intelligent devices can accomplish on behalf of people and how users can still be in control of their environment. This ambiguity ties in with the lack of seamless infrastructures and AmI applications on the market which could clarify this relationship. To consistently anticipate in real-time the needs, moods or desires of users, has been a key technical difficulty to-date. José et al. (2010) hint at this problem when they remark that there is:

> a persistent gap between the promises of the area and its real achievements. In particular, some of the central features of AmI, such as its anticipatory nature or strong personalisation, are not only far from being achieved, are also being increasingly questioned (José et al, 2010: 1482).

In a mission statement, Aarts and de Ruyter account for this gap somewhat differently by stating that development 'is still in its infancy […] due to the gap that exists between the fiction of the concepts resulting from the vision on the one hand and the intricacy of realization on the other hand' (Aarts and de Ruyter, 2009: 9). They report a 'revealing finding [...] that, in addition to cognitive intelligence and computing, also elements from social intelligence and design play a dominant role in the realization of the vision' (2009: 5). They reassert the notion of intelligence whereby context aware, personalized, adaptive and anticipatory intelligence (although not realized) needs to capture socialized, empathic and conscious social intelligence. Communication protocols should be designed to be compliant with conventions, follow manners and etiquette. Devices should demonstrate empathic awareness of emotions and motives by exhibiting understanding and helpful behavior. Finally, a system's reasoning should be consistent, transparent and conscientious to the user, to ensure trust and acceptance.

The vision of intelligence in AmI designs is taken here to a new level of complication in describing the conditions that *could* introduce what Aarts and de Ruyter refer to as *true intelligence*. Thus, AmI 2.0 applications demonstrate only a minute step in that direction, e.g., of facilitating users with the means for intelligent interaction, affective experience, but also control. The gap that still needs bridging, according to Aarts and de Ruyter, relates to the following design problems: 1) how to access and control devices in an AmI environment; 2) how to bridge the physical and virtual worlds with tangible interfaces; 3) What protocols are needed for end-user programming of personalized functionality; 4) how to capture and influence human emotion; 5) how to mediate social interaction for social richness, immediacy and intimacy; 6) how devices can persuade and motivate people in a trustful manner, say, to adopt healthier lifestyles, and; 7) how to guarantee inclusion and ethically sound designs. They believe that experience research holds the key to eventually bridging this gap between the fiction and concrete realizations. For example, understanding experience from a *deep personality point of view* will unlock unlimited possibilities to develop intelligent applications.

Concluding remarks

The AmI vision emerges from a pedigree of expectations about the future of computing. It holds a promise of increased productivity and efficiency with new kinds of functional complexity in human-device relations. The original scenarios are central to making up new worlds and building expectations around prospective lifestyles and users. Rhetorically, they contribute to conditions that make visions of AmI seemingly possible. But they also engender capacities to investigate what is actually possible. Incorporating new challenges and anticipating problems modulates the course of expectations. Questions of privacy and safety, the limitations of AmI prototypes in supporting real-life ordinary activities, even the *far-out-ness* of the vision, form part of a multidisciplinary dynamic of expectations. New visions are adapted to accommodate contingent futures—uncertainties about design principles, experiences, identities and preferences, changing socio-economic conditions and a growing demand for social responsibility and sustainable innovation. Visionaries and research leaders continue to imagine new socio-technical arrangements in which economic values and experiences are profoundly changing. The new interaction paradigm between people and technology will be embedded in an ecological utopia – the context and experience economy – based on values associated with intimate connections between people and things.

It is not our intention to make judgments about the prophecy of prospective worlds, articulated in AmI visions. Emile Aarts once stated that '[w]e need to continue evangelising the vision throughout Philips and Europe in order to make it come true' (Aarts, 2003: 5), and one can argue that a greater vision needs to be cultivated to sustain both research and business (or funding) interests. But our inquiry has been conducted to shed light on the many ways in which the AmI vision is performed and managed—to clarify the role of rhetoric, professional accounting, paradigm- and world-making, to communicate complex problems and address the issue of what people actually want. Our general finding is that the history of AmI represents a striking example of visionary work. It has the rhetorical, performative and generative power to harness technological, social-psychological, cultural, political and moral imaginations into a collective quest for novel reconfigurations of human-world relationships. In accordance with findings from expectation studies, attempts to bridge the gap between vision and reality fail and the future is postponed while the visionary work continues to inspire and motivate. The register of future lifeworlds changes constantly and we ask why that happens and how the promissory agents manage the tension between inspiration and momentum.

How a promissory organization of proximate and contingent futures sustains itself around a dominant vision is of some interest. But the more puzzling finding is how the promissory agents have deliberately complicated the AmI innovation program and explicitly addressed problems of credibility of artificial reasoning and interaction paradigms that are implicit to realizing AmI. Consequently, the delivery of intelligence is nevertheless postponed while the vision of *true intelligence* is rebuilt around new concepts and problems to solve (Aarts and de Ruyter, 2009). In this respect, it is therefore worth noting the role of ambiguity in managing the concept of intelligence in the vision's title, *Ambient Intelligence*.

The definitional looseness of a concept allows for expansion and/or modification of activities that aim to achieve what the concept *can* stands for, and in ways that are difficult to account for. But within the AmI narrative, the ambiguity of what intelligence stands for has provided productive pathways. For example, the early scenarios anticipated a breakthrough in artificial reasoning. They strongly implied that the inner workings of devices would demonstrate the intelligence to learn and adapt to human emotion and behavior in order to act on behalf of people without their explicit command. However, this anticipated presponsiveness was described cautiously as a *possibility*. Then, in the absence of a breakthrough, the intelligence is indefinitely postponed. We see disunity in articulation of what freedom from manual control of one’s environment stands for and the question is raised if people really want devices intercepting their emotions and ordinary goings-on.

The concepts of human and artificial intelligence are never neatly defined and, therefore, *intelligence* will always retain a definitional looseness to some degree. The AmI research community has not clarified the specific terms of what advanced sensory and information processing capabilities can actually do. Well-known failings of artificial reasoning are not accounted for either in the visionary work we have examined, only the specific failings associated with AmI designs and development in experimental settings. It is also of particular curiosity how the disappointments instigate shifts in reasoning. Everything *smarter* may simply be redundant if people want control rather than *strong* personalization. Strong personalization does not work well in social settings where *sharing* experience is what people naturally do. Researchers need to better understand what people want, how they take advantage of available devices, and how to craft devices and systems in ways that *intelligently* inserts them into ordinary everyday affairs—not just the affairs of one individual at a time, but into the ordinary interactions found in group activity or social settings more generally. The expansion of work over the years, to incorporate social intelligence and experience into AmI designs, most strongly exemplifies this shift in reasoning. But these developments, although productive, introduce a confusing set of issues with respect to what *true intelligence* stands for in prospective AmI systems and interaction paradigms (Aarts and de Ruyter, 2009).

One could argue that a loosely defined concept of intelligence would be counter-productive, if not outright dangerous. For example, there are uncertainties about the extent to which we can trust so-called intelligent devices in complex organizational settings where decisions are delegated to them in delivering critical health, safety or security services. Indeed, what the SWAMI group detected was the risk of outcomes involving unintended consequences which would be difficult to make subject to visible and legitimate accountability. But as the AmI narrative has evolved over time, we argue that disunity in assumptions about intelligence has indeed been productive. For example, devices can be designed to respond to or intercept people with courtesy, humor or normative suggestions without actually performing a courteous, humorous or normative reasoning as we typically understand and engage it. If the imitation is successful, chances are that people will respond to the make-believe by suspending their disbelief (see companion robotics, e.g., Coeckelbergh, 2010). Also, the more robust the understanding AmI developers have of sociality, what people are on about and how they go about their ordinary affairs, chances are that devices will not only be more intelligently designed but will actually contribute to a new everyday based on interaction paradigms that allow people to go more intelligently about their business. Perhaps the ultimate test is already presented in recent innovations, recognized by AmI visionaries and research leaders for solving many of the problems addressed in the original scenarios, e.g., smart phones. They facilitate the enactment of human intelligence and activities people actually want to engage in.

Where exactly the intelligence resides, how it is defined, distributed, or whether one or another form of intelligence will be achieved in future AmI systems and interaction paradigms, we do not provide an answer to. Rather, we conclude by emphasizing the unique agenda of the AmI research community, to improve our understanding of human sociality, experience, emotion and embodied situated reasoning, and we argue that this agenda has been at the heart of the AmI innovation narrative from very early on. Without solving the ancient riddle of intelligence, or the more recent riddle of sociality, continuous exploration, experimentation and re-invention of what intelligence *can* possibly stand for, has substantively contributed to the evolution and management of the AmI vision, and effectively sustained its appeal.

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