The Mundane Computer: Non-Technical Design Challenges Facing Ubiquitous Computing and Ambient Intelligence

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ABSTRACT

Interdisciplinary collaboration, to include those who are not natural scientists, engineers and computer scientists, is inherent in the idea of ubiquitous computing, as formulated by Mark Weiser in the late 1980s and early 1990s. However, ubiquitous computing has remained largely a computer science and engineering concept, and its non-technical side remains relatively underdeveloped.

The aim of the following is, first, to clarify the kind of interdisciplinary collaboration envisaged by Weiser. Second, the difficulties of understanding the everyday and weaving ubiquitous technologies into the fabric of everyday life until they are indistinguishable from it, as conceived by Weiser, are explored. The contributions of Anne Galloway, Paul Dourish and Philip Agre to creating an understanding of everyday life relevant to the development of ubiquitous computing are discussed, focusing on the notions of performative practice, embodied interaction and contextualisation. Third, it is argued that with the shift to the notion of ambient intelligence, the larger scale socio-economic and socio-political dimensions of context become more explicit, in contrast to the focus on the smaller scale anthropological study of social (mainly workplace) practices inherent in the concept of ubiquitous computing. This can be seen in the adoption of the concept of ambient intelligence within the European Union and in the focus on rebalancing (personal) privacy protection and (state) security in the wake of 11 September 2001. Fourth, the importance of adopting a futures-oriented approach to discussing the issues arising from the notions of ubiquitous computing and ambient intelligence is stressed, while the difficulty of trying to achieve societal foresight is acknowledged.

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1. The otherwise invisible: interdisciplinary collaboration

The late Mark Weiser described ubiquitous computing, now often called pervasive computing, as "the method of enhancing computer use by making many computers available throughout the physical environment, but making them effectively invisible to the user". [1] The notion of invisibility is crucial to Weiser's formulation. For example, elsewhere he asserts, the "most profound technologies are those that disappear." [2] The manner of this invisibility or disappearance is not primarily that of concealment, although many of the workings of ubiquitous computing may indeed be hidden from view, but familiarity. Such technologies are so familiar, so much a part of everyday life, that they are no longer a focus of conscious attention. In other words, they "weave themselves into the fabric of everyday life until they are indistinguishable from it". [3].

The notion of invisibility suggests to Weiser a possible role for disciplines beyond the natural sciences, engineering, and computer science in the development of ubiquitous computing:

> "To understand invisibility the humanities and social sciences are especially valuable, because they specialise in exposing the otherwise invisible. For instance, ethnography can

teach us something of the importance of the details of context and setting and cultural background; feminist deconstructionism can teach us a little of the necessity of different, deeply lived, points of view to real understanding". [4]

This is not the only role that Weiser envisages for disciplines outside of computer science in the development of ubiquitous computing, however. He also envisages an evaluative role. This arises from Weiser's view of how ubiquitous computing can be developed in practice. For Weiser, Phase I of ubiquitous computing is "to construct, deploy, and learn from a computing environment consisting of tabs, pads and boards". [5]

Tabs, pads and boards represent three different scales of ubiquitous computing device. The board is a wall-sized interactive surface, analogous to the office whiteboard or the home magnet-covered refrigerator or bulletin board. The pad is analogous to scrap paper to be grabbed and used easily, with many in use by a person at once. The tab is a tiny computer, analogous to Post-It notes, but also like the displays of words found on book spines, light switches and hallways. For each person in an office, the location discussed by Weiser, he conceives that there would be hundreds of tabs, tens of pads and one or two boards.

Weiser sees tabs, pads and boards as forming a substrate, or infrastructure. When it is in place, progress can be made both in evaluating these technologies and in determining the next steps to be taken. Phase I, Weiser asserts, "is unlikely to achieve optimal invisibility", but, "it starts down the radical direction, for computer science, away from attention on the machine and back on the person and his or her life in the world of work, play, and home." [6]

It is in this context that the evaluative role for other disciplines lies. For Weiser,

> "A key part of this evaluation is using the analyses of psychologists, anthropologists, application writers, artists, marketers, and customers. We believe they will find some things right; we know they will find some things wrong. Thus we will begin again the cycle of cross-disciplinary fertilization and learning. Ubicomp seems likely to provide a framework for interesting and productive work for many more years or decades, but we have much to learn about the details" [7]

Thus, Weiser conceives two distinct roles for disciplines outside of the natural sciences, engineering and computer science in the development of ubiquitous computing:

- evaluation of the designed technological device, the physical technology, and its deployment in practice; and
- understanding everyday practices, particularly the play between the visible and the invisible (or taken-for-granted), in bringing certain phenomena to conscious attention.

Weiser establishes that if ubiquitous computing is to be further developed it will require interdisciplinary collaboration, and that that collaboration involves cyclical or iterative cross-disciplinary fertilisation and learning.

The first major challenge in designing and developing ubiquitous computing, then, lies in establishing a cycle of learning and collaboration, which can accommodate and integrate a range of differing and divergent design and research practices, and consolidating that learning. These practices range from the specificity of device-led computer science and engineering experiment; through the design of the built environments which house and situate the human practices to which technological devices could contribute; to the open-ended, philosophical-anthropological study of context and social practice of which technologies are important elements, including practices of reflexive self-awareness whereby people examine their engagement in instrumental action and social and symbolic interaction.

The difficulty, partly due to differences in focus or emphasis and to different understandings of the material and social worlds and how to act upon and through them, also reflects different understandings of

purpose and motivation in relation to the development of computer technology, for example as an end in itself (engineering research), as an element in work practice (instrumental, applied or economic research) or as an aspect of communicative social practices more generally (research on media, communication and society).

Such collaboration will not be easy. Furthermore, the institutional location of such collaboration, for example the university laboratory, the research and development department of a multinational enterprise or the workshops of a medium-sized design company, will influence the balance among research directions. For example, the research may be technology-led, focusing on technical feasibility. It may be commerce-led, in pursuit of business goals such as efficiency and profitability. It may be government-led, focusing on national macroeconomic objectives such as productivity growth. It may be design-led, in pursuit of human-computer interaction goals evaluated in terms of utility or aesthetics. It may be information-led, in seeking to understand the processes of learning and human knowledge creation. Finally, it may be society-led, in pursuit of such overarching values as sustainable development, social equity or social mobility.

The institutional location will also impact on the degree to which the arts, humanities and social sciences, including the many emergent fields of design practice such as design of narrative environments, interaction design and design of smart textiles, contribute creatively to the development of ubiquitous computing, beyond having a secondary evaluative role in relation to technology development or a role as supplier of data which technology creators may take into account. From Weiser's perspective, the natural sciences, engineering and computer science provide the creative impetus, while the arts, humanities and social sciences provide secondary inputs, such as evaluation and data. Effective collaboration would aim, to paraphrase Weiser, to integrate the natural sciences, engineering, computer science, the arts, design, humanities and social sciences until they are inseparable from one another.

Such collaboration is beginning to emerge, for example Phoebe Sengers et al. [8], at the Cornell University Information Science programme, use interdisciplinary groups to develop what they call culturally embedded computing. Sengers' group includes researchers from computer science, user interface design, social science, cultural studies, architecture and product design.

While the issue of cyclical, interdisciplinary collaboration is beginning to receive the attention it deserves, the issue of how to consolidate the interdisciplinary learning arising from that collaboration is yet to receive its due attention. It will involve issues of information management, such as establishing interdisciplinary knowledge architectures, and knowledge management, for example sophisticated systems which integrate dynamically abstract knowledge and embodied, personalised competences.

2. Ubiquitous?

For Weiser, the common metaphors of human-computer interaction prevalent in the early 1990s led away from the invisible tool and towards making the tool the centre of attention [9]. The first metaphor he discusses is 'multimedia'. He defines this as the idea that since computer interfaces should be attractive, and television is attractive, television-like multimedia functions should be put into computers. Such attractiveness, Weiser argues, is the opposite of invisibility, distracting the user from any task they may be seeking to accomplish.

A second metaphor he discusses is intelligent agents, in which the ideal computer is like a human being, only more obedient. Weiser notes that,

> "A computer I need to talk to, give commands to, have a relationship with (much less be intimate with), is a computer that is too much the center of attention." [10]

A third metaphor Weiser discusses is virtual reality, the idea that by moving to full-body-sensing and interaction, the user interface problem will be solved by maximally utilising all of our body's input and

output channels. For Weiser, the problem here is that virtual reality,

> "by taking the gluttonous approach to user interface design, continues to put the interface at the center of attention, leaving the real world behind" [11]

The general problem with such lines of research, Weiser asserts, is that "they are all in the domain of the conscious interaction". Instead, he would rather pursue "techniques of invisibility" to create "the mundane computer". [12]

On the basis of these reflections on research in computer science, Weiser set out a number of goals for ubiquitous computing. These are, as paraphrased by Anne Galloway: [13]

- to liberate people from the constraints of desktop computing;
- to free people from isolating immersive and simulated virtual reality environments;
- to build computers that do not interfere with people's everyday activities; and
- to weave information and computing technologies into the fabric of everyday life until they are indistinguishable from it.

Galloway interprets Weiser's texts as saying that,

> "ubiquitous computing was meant to go beyond the machine - render it invisible - and privilege the social and material worlds. In this sense, ubiquitous computing was positioned to bring computers to 'our world' (domesticating them), rather than us having to adapt to the 'computer world' (domesticating us)." [14]

In other words, the implicit goal is to assist everyday tasks, not overwhelm them or deform them into patterns more suited to the computer than to people, by shifting the site and the style of the interaction between people and computers beyond the desktop and into the larger real world where people live and act.

In the view articulated by Galloway, derived from Weiser's texts, the context for ubiquitous computing has widened from the workspace to the everyday/everywhere. In his practical experiments, Weiser sought to disperse computing facilities around the workspace, using the notions of the 'everyday' and the 'real world' to stand for 'work' and the 'workspace', on the basis that work is an everyday practice for most people and that work, for most people, takes place in a specific work location. He also mentions the domains of 'play' and 'the home', but the main focus is the task and the workplace. The ambiguities of the language and metaphors used by Weiser to describe the vision of ubiquitous computing mean that it could operate both as a computing paradigm, in the context of rearticulating work practices, and a social paradigm, in the context of rearticulating everyday life. [15]

Galloway's characterisation is, therefore, a valid interpretation of Weiser and there is sufficient ambiguity in Weiser's texts for it to be unclear whether his ultimate goal was a technological revolution or a technology-led social revolution, or whether he believed that the former leads to the latter in some inevitable way.

This slippage, from 'the workplace' to 'the world' and from the tasks of the workplace to everyday social practices, partly accounts for the vagueness and inadequacy of ubiquitous computing as a social paradigm. Its initial scope was to transform some of the tasks undertaken at work, to make tasks simpler by making the workplace smarter. Weiser has little to say about the actual processes by means of which workplace change effects wider societal changes.

In the meantime, since Weiser wrote his texts, continued technological advances, for example in miniaturisation, processing power and wireless connectivity, mean that the overextended metaphor of ubiquitous computing as a sociotechnical paradigm, with all its weaknesses, is being taken more seriously, as Jurgen Bohn et al. indicate. [16]

The second major challenge for the design and development of ubiquitous computing concerns its vision: the spatio-temporal extent of the 'where'-abouts and 'when'-abouts of its 'everywhere'; and the extent of its ambition concerning technological change and social change. Distributing processing and networking power about the workplace, the home and in some traffic systems in some countries does not constitute 'everywhere'. The 'ubiquity' of ubiquitous computing has limits. The vagueness of the vision of ubiquitous computing leaves it open to being interpreted as a variety of technology-led absolutism, totalitarianism or authoritarianism [17]. Part of the reason that its vision is unclear may be that immediate objectives, for example to make tasks simpler, are not distinguished from ultimate objectives, such as creating a fairer society by spreading particular competences, previously exclusive, to wider societal groupings. Its vision raises issues pertaining to the relationship between the control of technological systems and systems of social control, another area in which the ambiguity of the language used to explore the idea of ubiquitous computing encourages slippage. In other words, design and development of ubiquitous computing needs to address explicitly both its technical vision, and questions of technical feasibility and control, and its social vision, with its implications for social control and societal development, both its immediate aims and its ultimate objectives. [18]

3. Ubiquitous computing, context-aware computing and ambient intelligence

If ubiquitous computing is to be dispersed not just around the workplace but elsewhere, the challenge, as Moran and Dourish [19] indicate, is

> "to make computation useful in the myriad various situations that can be encountered in the real world - the ever-changing context of use."

Furthermore, Albrecht Schmidt [20] makes it clear that,

> "…context is essential for building usable Ubiquitous Computing systems that respond in a way that is anticipated by the user. Context-awareness becomes a fundamental enabling technology for Ubiquitous Computing and is a key issue when creating computers that are invisible and disappear in terms of user perception. In these terms context-awareness goes beyond providing context information, it also requires understanding context and ultimately understanding situations."

Moran and Dourish concur that for those working in ubiquitous/pervasive computing context-awareness is crucial to their efforts to disperse and enmesh computation into people's lives. Context is taken to refer to the physical and social situation in which computational devices are embedded, and one goal of context-aware computing is to acquire and utilise information about the context of a device to provide services that are appropriate to the particular people, place, time, events, and so on.

Paul Dourish [21] identifies two strands of context-aware computing within human-computer interaction research. The first is primarily technical, focusing on physically-based interaction and augmented environments. The major exemplars in this strand are Weiser's ubiquitous computing and Ishii and Ullmer's Tangible Bits [22] . Although differing in emphasis, these two approaches share several features: they seek to exploit people's natural familiarity with the everyday environment and their spatial and physical skills, so that computation can be used in concert with naturalistic activities; they use spatial and temporal configurations of elements and activities in the real world to disambiguate actions, to make computational responses a better fit for the actions in which users are engaged; and they look for opportunities to tie computational and physical activities together in such a way that a computer withdraws into the activity, so that users engage directly with the tasks at hand and the distinction between interface and action is minimised.

The second strand of context-aware computing focuses on developing interactive systems around understandings of the generally operative social processes of everyday interaction. In this strand, the emphasis is on the relations between human-technology interactions and the social settings in which those

interactions unfold. This strand moves towards what is called in Europe ambient intelligence.

While ubiquitous computing is only a social paradigm by metaphorical overextension, remaining primarily a technical concept, the same cannot be said of the notion of ambient intelligence. The European Union, for example, uses the notion of ambient intelligence in an attempt to define a future social and economic space which is increasingly pervaded by computing intelligence as the 21st century unfolds. [23]

Nigel Shadbolt [24] notes that in order to deliver environments rich in ambient intelligence, convergence of several computing areas is required: ubiquitous or pervasive computing, i.e. ad hoc networking capabilities that exploit highly portable or numerous, very-low-cost computing devices; intelligent systems research, for example learning algorithms and pattern matchers, speech recognition and language translators, and gesture classification and situation assessment; spatial context awareness, tracking and positioning objects of all types and representing objects' interactions with their environments; and social interaction, involving appreciation of the social interactions of objects in environments.

For Shadbolt, the overall challenges in developing ambient intelligence are to understand how people live their lives and to understand how they use the spaces in which they live, to create particular 'places'.

Shadbolt's outline of the computing convergence required for ambient intelligence indicates that ubiquitous or pervasive computing is only one part of the mix. Aarts [25] elaborates on the distinction between the two terms,

> "Ambient intelligence aims to take the integration provided by ubiquitous computing one step further by realising environments that are sensitive and responsive to the presence of people."

For Aarts,

> "Ambient intelligence is more than just a question of embedding technology into objects. It involves human culture in its broadest sense; universal desires; complex social relationships; diverse value systems; individual likes and dislikes; the sustainability of economic and natural ecosystems; and codes of ethics, conduct, and communication, both in civil society and business."

As Shadbolt indicates, ambient intelligence, in the early 2000s, is far from being a facet of everyday life. It remains at the research stage. The leading developers have been Philips (http://www.philips.com/research/ami) and MIT (http://oxygen.lcs.mit.edu). Organisations researching ambient intelligence include institutes such as Ireland's National Microelectronics Centre (http://www.tyndall.ie/research/mai-group/aes_mai.html), VTT Electronics (http://www.vtt.fi/ele/indexe.htm) and the Fraunhofer IZM (http://www.izm.fhg.de). Ongoing projects addressing software, infrastructure and design challenges for ambient intelligence include the Aware Home (http://www.cc.gatech.edu/fce/ahri) at Georgia Institute of Technology, Aura (http://www-2.cs.cmu.edu/~aura) at Carnegie Mellon University, Endeavour (http://endeavour.cs.berkeley.edu) at University of California at Berkeley, Portolano (http://portolano.cs.washington.edu) at the University of Washington, Cooltown (http://www.cooltown.com/cooltown/index.asp) at Hewlett Packard, Jini (http://wwws.sun.com/software/jini) at Sun, PIMA (http://www.research.ibm.com/PIMA) at IBM Research, and the Semantic Web (http://www.semanticweb.org) at W3C. Research is also underway at Xerox PARC (http://www.parc.com) and in a number of companies funded by the Defense Advanced Research Project Agency (DARPA). Microsoft Research (http://research.microsoft.com) Microsoft Research is also conducting research into ambient intelligence, particularly in larger-scale spaces such as office buildings and public places (corporate campuses and airports).

Within the European Union (EU), two projects related to ambient intelligence are already underway. They are the Ambience Project, which was initiated as part of the Information Technology for European Advancement (ITEA) programme, itself part of the pan-European intergovernmental EUREKA initiative

[26] . The Ambience Project (http://www.hitech-projects.com/euprojects/ambience/) is led by Philips. The other is the Disappearing Computer (http://www.disappearing-computer.net), a proactive initiative of the Future and Emerging Technologies activity of the Information Society Technologies research programme (http://www.cordis.lu/ist).

A major step in developing the vision of ambient intelligence in Europe came from the Information Society Technologies Advisory Group (ISTAG). In 1999, ISTAG published a vision statement for the European Community Framework Programme 5 for Research and Technological Development (FP5). Following the work of ISTAG and other consultative procedures organised by the European Commission, ambient intelligence became the key concept in the European Community Framework Programme 6 for Research and Technological Development (FP6) for the period 2002-2006. The FP6 is the EU's main instrument for the funding of research in Europe. The main focus of FP6 is the creation of a European Research Area (ERA). Ambient Intelligence in Everyday Life (AmI@Life) is one of two pilot science and technology roadmaps under development at the Institute for Prospective Technological Studies of the European Commission's Joint Research Centre in collaboration with the European Science and Technology Observatory network. (See http://fiste.jrc.es/download/AmIReportFinal.pdf.)

The overall vision in Europe is that the Information Society Technologies thematic priority will contribute directly to realising European policies for the knowledge society as agreed at the Lisbon Council of 2000, the Stockholm Council of 2001, the Seville Council of 2002 and as reflected in the e-Europe Action Plan. The strategic goal for Europe in the 2000s 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. [27]

The Lisbon strategy is seen as a means to enable the European Union to give a positive response to the new conditions defined by economic globalisation in the post-Cold War era, technological change and population ageing. Such a strategy would take advantage of that technological change, define a European way to a knowledge economy and restore the prospect of more and better jobs. According to Rodrigues [28],

> "The Lisbon strategy can be understood as a strategy for economic and social modernisation in the light of European values. This strategy encompasses various policies: information society, research, innovation, enterprise, financial market, education and training, employment, social protection and social inclusion".

For the EU's ISTAG, the concept of ambient intelligence,

> "provides a vision of the Information Society where the emphasis is on greater user-friendliness, more efficient services support, user-empowerment, and support for human interactions. People are surrounded by intelligent intuitive interfaces that are embedded in all kinds of objects and an environment that is capable of recognising and responding to the presence of different individuals in a seamless, unobtrusive and often invisible way." [29]

The ISTAG argue that if ambient intelligence is to be successful as the future techno-economic trajectory of development, it will also have to be seen as a positive force for the societal and political development of Europe. Thus, for the ISTAG, ambient intelligence,

> requires more than computer science. It can only be fully developed by a holistic approach, encompassing technical, economic and societal research." [30]

Overall, the social aspects of ambient intelligence raise major issues that require precautionary research, particularly in the areas of privacy, control and social cohesion, the ISTAG contend. Furthermore, encouragement may be needed to develop forms of ambient intelligence that are sensitive and adaptive to societal development and the diversity of European social, political and cultural life. In order to release the potential socio-political gains from, and the economic potential of ambient intelligence, significant

and underpinning research of a focused nature will be required, including research into socio-technical design factors, support for human-to-human interaction and the analysis of societal and political development.

The notion of ambient intelligence, then, articulates explicitly some of the dimensions missing from the notion of ubiquitous computing, if it is to operate as a social paradigm. It also suggests, given the plethora of initiatives, structures, committees and groups implicated in the context of the EU, just how complicated developing ambient intelligence as a societal vision would be.

The third major challenge for the development of ubiquitous computing, now as part of ambient intelligence, is to understand how and why technologies are adopted and diffused throughout society and across countries, such that they might become commonplace. If ubiquitous computing can be said to imply a technologically deterministic and utilitarian view of technology development and its societal dissemination, then ambient intelligence might be said to imply an overly bureaucratic view of how technologies are developed and disseminated.

In the technology-centred view, engineers create technologies that are so useful that they are widely adopted. The actual processes of dissemination are not defined precisely. In the bureaucratic view, governments, for example in the form of EU decisions interpreted by member state governments, and large corporations, such as Philips, conceive the direction of and goals for technology development, while implementation is secured through research contracts involving collaborations between corporations of various sizes and academic institutions in the Framework Programme. Technologies become widespread because, once developed, they are marketed to appeal to corporate and consumer need and desire, on the basis of a mixture of utility and symbolic value. Given the existing levels of public scepticism towards corporate advertising, marketing and globalisation and towards European integration (Euroscepticism), the limitations of the bureaucratic view of dissemination are readily apparent.

Design and development of ambient intelligent environments, if they are to become commonplace but not insidious, may need to take into account a wide range of factors relating to technology, government, corporate enterprises, markets, the nature of demand and the nature of corporate, household, private and public consumption, as well as the nature of public and private goods.

4. Europe in the post-Cold War, post 11 September 2001 globalising era

Significantly, the ISTAG scenarios document, *Scenarios for ambient intelligence in 2010*, was issued in February 2001. In July 2003, the Institute for Prospective Technological Studies (IPTS) issued a report with a different emphasis: *Security and Privacy for the Citizen in the Post-September 11 Digital Age: a Prospective Overview* [31]. In this report, the hypothesis is that the balance between an individual's freedom, reflected in the protection of their privacy, and the needs of the state to maintain law and order through appropriate security policies, a balance that has been built up over time within the framework of Europe's democratic societies, is shifting. The report argues that a combination of two factors is shifting that balance. Those factors are emerging information and communication technologies and their commercial and governmental applications; and governments' actions in response to rising organised crime and terrorism.

Three areas of technology are particularly important in the context of this shifting balance between individual privacy and state (or national) security, the report contends. They are identity-related technologies, e.g. identity management systems, radio-frequency based identity devices and biometrics; location-based services, in which mobile communication devices, notably mobile phones, provide services to users based on where they are located; and ambient intelligence technologies. The vision of ambient intelligence, the document states, requires a new security paradigm and new privacy measures.

As can be recognised, we are a long way from the small-scale ethnographic study of work practices and home-based tasks. The major contextualising horizon is no longer the workplace or the home, but has

become the nation state and the dynamics of international relations. One may be performing a particular task in a specific location, but one may also be performing 'national security', and possibly some form of nationalism, for example through the performance of a 'patriotic' act. At the same time, it might be difficult to decide whether one is performing a 'patriotic' act or a racist act. As well as performing in the theatre of racial politics, one may also be performing on the stage of global politics. For example, one may be taking up a symbolic position, through one's behaviour, in the globalisation/anti-globalisation debate. One's actions may seem to suggest that one supports a purported "neoliberal economic orthodoxy", even though that is far from one's conscious mind (attention) and is not the matter at hand. Alternatively, one may seem, for example from the manner of one's dress, to support a 'politics of resistance', or so it may be assumed by those with whom one shows solidarity or by those whose job it is to police the social order. [32]

From this perspective, the everyday is globalised. Two of the major events in this globalising context are the end of the Cold War in 1989-1991, indicating the emergence of a single, very unevenly developed and immensely problematic human and economic space, and the events of 11 September 2001, itself refracting an aspect of that uneven development. Yet, experientially, the everyday remains localised or proximate, located and situated. Actions, although often enacted simultaneously, differ in their nature and consequence, unfolding according to different spatial, temporal, practical, symbolic and institutional horizons.

The fourth major challenge for the design and development of ubiquitous computing, but moreso that of ambient intelligence, is to create an understanding of contextualisation, the processes whereby specific locations, situations, institutions and conjunctures, i.e. particular spatio-temporal contexts at different scales, and specific human 'selves' are created, sustained and inter-related. Crucial to such understanding is a sense of how such contexts re-mark one another ecosystemically through social practice. Furthermore, this abstract understanding of contextualisation will have to be related to the concrete, socio-historical realities of the world of the 21st century, and the socio-economic changes which it is undergoing, while addressing people's differing situated, motivated understandings of that reality and those changes (as mediated through their senses of self-hood).

5. The research agenda

In thinking through the notion of context-awareness, consideration is needed of how contexts bleed: outwards through geo-physical extension; inwards through reflexive intension and intention; and paradoxically, and potentially absurdly, as the outside and inside and the extensive and intensive interpenetrate, creating motivation and purposiveness. The dimensions of our actions vary greatly, depending on context. Context stretches beyond what we are aware of consciously. Our actions may not have the consequences we intend. Our individual performances affect the character of the ensemble of practices to which they contribute, but not in ways that we control.

Through context-awareness, ambient intelligent environments might help us to make finer judgements about our actions, so that we may alter them more in line with out intentions, as we begin to understand more fully the (ever-ramifying) implications of what we are doing individually (psycho-dynamically and inter-subjectively), collectively (in the form of institutional regularities) and globally (in the form of aggregate behaviours). Ambient intelligent environments might also help us to identify the potentially absolutising, fascisising or totalitarianising directions of our intentionality, enabling greater self-criticism. Such environments, by helping us to perform definite tasks may enable us to do much more qualitatively or quantitatively, depending on what is more appropriate, given the context of development. If this is the case, development of context-aware computing may indeed be justified. Even so, we still have to remain alert to the potential price of such technological progress in terms of our societal, or 'civilisational', development, our human agency and empowerment, our quality of life and our quality of experience, refusing simply to equate technical progress with economic development, societal development, human development and personal development.

Developing such vigilance requires not just criticising ubiquitous computing and ambient intelligence but engaging with them which, in turn, means engaging in collaborative research to consider feasible and desirable directions for development.

The design of ubiquitous computing and ambient intelligence needs to address issues relating to interdisciplinary learning and collaboration, consolidation of interdisciplinary learning to create new 'knowledges', the relationships between abstract knowledge and embodied competences, the actual, limited whereabouts of 'everywhere', the immediate aims and the ultimate objectives of ubiquitous computing and ambient intelligence, how and why complex technologies are disseminated and adopted, the process of contextualisation and the processes of socio-historical development, whereby technical change is related to personal development, human development, societal development, economic development and environmental change.

The challenge is immense. The following concepts, derived from the existing literature on ubiquitous computing and ambient intelligence, may help us begin to address that challenge and to design specific research projects, but they are far from providing a comprehensive taxonomy.

5.1 Everyday life

One way of expressing the overall challenge facing ubiquitous computing and ambient intelligence, as a mixed computer/social paradigm, is to say that an understanding of 'our world', 'the everyday' or 'everyday life' is needed, to facilitate the design and development of effective ambient intelligent environments. The difficulty in creating an understanding of everyday life is not lack of evidence or available approaches but over-abundance of interpretations of the everyday. As Barry Sandywell [33] points out, everyday life is a central, highly diverse and problematic theme for modern philosophy and social theory. The analysis of the everyday has been undertaken by such thinkers as Dilthey, Wittgenstein, Simmel, Husserl, Schutz, Heidegger, Dewey, Lefebvre, Kosik, Bakhtin, Benjamin, Bloch, Habermas, Garfinkel, Debord and de Certeau. There are potentially valuable insights within each interpretation which could contribute to the creation of a set of understandings to aid the design of ubiquitous computing. To combat potential information overload, a practice-centred approach to the everyday is taken in what follows.

5.2 Performative practice

For Anne Galloway, everyday life is a question of performative practice. Performativity involves spatialisation, temporalisation, embodiment, identification and sociality, the processes by means of which space, time, bodies, identities and socialities, essential to being-in-the-world, are performed. She also notes that ubiquitous computing raises issues relating to power and control in everyday life. Those involved in the development of ubiquitous computing, she states,

> "need to be clear on, and be able to justify, what it is about the mundane nature of everyday life that can be 'improved' through augmentation, amplification or attempts to merge the physical and the virtual - especially if the technologies themselves are expected to become ordinary and pervasive aspects of everyday life." [34]

Galloway's understanding of the everyday is that it is constituted in and through a field of "sociotechnical assemblages", spaces of performative interaction and intersubjectivity. The social and the technical are already interwoven in concrete, located social and cultural practices. Ubiquitous computing intervenes in a field already mediated by existing social practices and their respective technologies. From Galloway, then, we may extract a principle of performative practice, while context is understood in broad terms as a field of socio-technical assemblages. She also raises the concepts of power and control, which can be understood in both social and technical terms.

5.3 Embodied interaction

To develop further understanding of performative practice and sociotechnical assemblages, in the context of the design and evaluation of ubiquitous computing and ambient intelligence, the work of Paul Dourish [35] is valuable. As already mentioned, Dourish identifies two strands of context-aware computing, the one primarily technical and the other emphasising the relations between human-technology interactions and the social settings in which those interactions unfold. He identifies the key idea that ties these two programmes of work together is that of embodied interaction. As Dourish explains it, embodiment is about both what people do in the world and about how those actions accomplish meaningful events, socially and subjectively, and, in turn, are understood by others as being meaningful.

This idea is developed from the work of Lucy Suchman [36] which draws on Garfinkel's ethnomethodology [37], an approach which explains the orderliness of social conduct in terms of the practical achievement of group members continually working to render the whole sensible and interpretable in the course of their everyday actions. For ethnomethodology, social conduct is orderly because people make it so. Thus, investigation of social order involves the careful examination of specific instances of organised action so as to be able to uncover the means by which people produced the rationality that they exhibit.

The ethnomethodological perspective suggests that the context in which actions take place is what enables people to find it meaningful. Context, organisational as much as spatial/physical, plays a crucial role in shaping action and in providing people with the means to interpret and understand action. Because the meaning of action is determined interactionally, temporal context is also involved, as actions and utterances gain their meaning and intelligibility from the way in which they figure as part of a larger pattern of activity.

For Dourish, taking a lead from phenomenological philosophy and ethnomethodology, the meaning of a technology is not inherent in the technology but arises from how that technology is used. The significance of this for the design of interactive systems is that the designer does not have absolute control, only influence. In turn, this suggests that if the meaning of the use of the technology is, first, in flux, and, second, something that is worked out again and again in each setting, then the technology needs to be able to support this sort of repurposing, and needs to be able to support the communication of meaning through it, within a community of practice.

Dourish's emphasis on embodiment highlights that the design of ambient intelligent environments should not ignore the inter-related bio-physical and psycho-dynamic dimensions of bodies, individually and collectively, in specific spatio-temporal contexts, and should aim to sustain bodily 'health', in its many dimensions.

5.4 Instrumental and symbolic interaction

A major conceptual and practical difficulty for context-aware computing is that physical and human contexts, while analytically separable, are inseparable in performative practice and embodied interaction. The example of eating may clarify this point constructively. Steven Shapin [38] points out that eating is an instrumental act, and is understood as such. People eat to fuel the body and foods serve their purpose in supplying the body's energy needs. However, eating is much more than its bio-energetic function. Food is saturated with culture. Shapin notes that much of the substance of moral and social order is made up by the practices attending the production, preparation and ingestion of food. Thus, foods are clean and unclean or nutritious or non-nutritious. Foods define racial, religious, national, class and cultural identity. Most fundamentally, Shapin continues, eating is a moment of ontological transformation. It is when the not-you, i.e. not rational and not animate at the time of consumption, starts to become you, the rational being which ultimately decides what to consume.

Furthermore, the material transformation is simultaneously the possibility of social and moral transformation or the advertisement of the social and moral states to which a person lays claim. For example, a temperate person is one who eats temperately, respect for life is shown by vegetarianism and

those of high status eat later than those of low status. Shapin concludes that self-nourishing and self-fashioning, both instances of performative practice, occur at the same time. Such insights can be further developed through symbolic interactionism and ethnomethodology, both of which highlight reflexivity, the idea that people's accounts of everyday behaviour are not only reflexive and self-referring but also socially constitutive of the situations to which they refer [39].

5.5 Architectures, practices, institutions

Both Galloway and Dourish grasp the nettle of context, seeing context as complicating and interweaving physical, spatial, temporal, social, cultural, psychological, organisational and interactional factors. The work of Philip E. Agre [40] can be used to reinforce the insights of Galloway and Dourish, in the context of understanding the interpenetration of the physical and the human and the instrumental and the symbolic for the purpose of designing and developing context-aware computing and ambient intelligent environments.

Agre recognises that wireless information services, or technologies of connectivity and continuous presence as he calls them, complicate the analysis of context for the purposes of designing context-aware computing. He points out that such services, for example mobile phones, loosen the traditionally more fixed relationships between institutions and places, i.e. historically accreted complexes of practices and meanings.

New technologies of connectivity establish modes of connectivity that are continuous but peripheral. All of a person's relationships can be constantly present. Divided attention becomes the norm, Agre argues, an insight which evokes Ulrich Beck's concept of hybrid identity, whereby people move freely among multiple identities in a way partly of their own choosing, but which may lead to conflict and confusion. [41]

To provide a means for taking such phenomena into consideration in the design of ubiquitous computing, Agre suggests a three-level analysis. The first level is that of architecture (or the built environment). The primary focus is on fixed structures, e.g. buildings, walls, corridors, doors, windows, and so on, but physical objects, such as furniture and appliances, are included if they are confined to a single location. The second level is that of practices. These are ensembles of embodied routines or actions that a particular group or community of people has evolved for performing particular activities in a particular place. Practices can be differentiated by scale (size of participant grouping). At the micro scale, the example Agre suggests is that of the customary greetings and debriefings that a married couple engage in when they arrive home from work. Ways of attending the theatre provide an example of a practice at the macro scale. The third category is that of institutions. These are defined as the persistent structures of human relationships; or, ensembles of roles and rules that constitute these relationships. Examples of institutions include the medical system, the university, marriage, intellectual property, language and religion. Institutions create categorial and interpretive frameworks for practices. Alternatively, it can be said they provide the rules for the game. As can be seen from the examples, institutions, too, can be differentiated by scale. [42]

5.6 Encoding/decoding: structuration, duration and habitus

The important point that Agre makes is that the architectural/designed/built environment 'maps' or encodes the institutional environment, while both provide resources and constraints for practices. By emphasising agency, in the form of practices, and structure, in the form of architectures/institutions, Agre's mode of explanation is evocative of that of Giddens [43], who uses the notion of structuration to discuss the interrelationship of action and structure, locating the capability of actors in the context of structure as medium and outcome of agency and interaction. Giddens' thought may also be useful in developing Agre's concept of practice, allowing it to be seen as a continuous flow of action and cognition in which both structure and agency play a part. In this way, the short-term spatio-temporal duration of

practice (*durée*) can be distinguished from the long-term spatio-temporal duration of institutions, architectures and socio-historical periods (*longue durée*).

Agre's discussion of practice would also benefit from Bourdieu's [44] notion of habitus. For Bourdieu, the habitus consists of a set of classificatory schemes and ultimate values which are the means by which groups endeavour to impose ways of seeing favourable to their own interests. Such discussion may prove useful in elaborating the play of the visible and the invisible in the everyday, a notion raised by Weiser. The notion of habitus is embedded in a discussion of social class for Bourdieu, and practice for Bourdieu is primarily a matter of the practices of a class or class fraction. Each habitus is set by historical and socially situated conditions and allows new forms and actions, but is far from allowing the creation of unpredictable or unconditioned novelty.

Each of these concepts, encoding, structuration, duration and habitus, has a contribution to make to a more adequate understanding of contextualisation, while each of these abstractions would be clarified and developed through a practical research project pursuing the creation of ambient intelligent environments.

5.7 Contextualisation: location, situation, institution and conjuncture

Agre, Dourish and Galloway all highlight the importance of social practices, whether understood as performative practice or embodied interaction. Agre highlights the importance of long-running contextual factors, both at the physical/spatial level and the human/social level, in the forms of the built environment and the institutional environment. He also draws attention to the interpenetration of the physical/spatial and the human/social, using the metaphor of mapping. Through this interpenetration, or mutual encoding, specific 'places' or 'contexts', in which social practices are performed, are created, as spatialities and as temporalities, as Galloway has pointed out.

For the purposes of creating a research agenda, four categories of context, of which context-awareness may be generated and encoded, are distinguished: the relatively long-term but relatively static context of location (three-dimensional Cartesian or Euclidean spaces or architectures); the relatively short-term but very dynamic, and often-repeated, context of practices, articulated as situations; the relatively long-term, but malleable, context of institutions; and the relatively long-term and relatively slow-moving socio-historical conjunctures (moments or periods of history) they constitute.

Much of ubiquitous computing remains at the level of location-awareness, but if it is to operate in ambient intelligent environments, it will begin to encode situational-awareness, institutional-awareness and conjunctural-awareness into its field of operations. Through what Agre calls 'mapping', location-awareness already operates as, for example, institutional-awareness, but does so in a possibly reductionist manner, in as far as architectural change may not keep pace with institutional change: its 'map' or code may not be sufficiently dynamic, causing difficulties for responsive decoding.

5.8 Institutional order and conjunctures

While the focus on practice, performativity, embodiment and interaction is vital for understanding the constitution of specific spatio-temporal realities and human identities, they should not be interpreted in a narrow instrumental way, such that the larger-scale and longer-running spatio-temporalities, Galloway's "sociotechnical assemblages", become obscured. [45]

To develop this idea from Agre's scheme, institutions/architectures relate to one another at the level of the institutions themselves, as well as through transfers brought about by individuals' behaviours in crossing institutional boundaries. For example, the theatre relates to other cultural institutions such as the art gallery, the museum and the cinema both as complementary (from the point of view of education and culture) and as competitive (from the point of view of audience attention, revenues and societal resource allocation). The theatre also relates to other forms of institution, for example financial institutions, political institutions, institutions related to industrial, service and agricultural economies, and sporting

institutions.

Overall, the complex patchwork of inter-relationships of institutions among themselves forms an institutional order, through which power, influence and control are channelled in large-scale, mass societies. This macro-social dimension, the conjunctural, societal whole which orients institutions, gives them their particular, but relative, socio-cultural role, and constrains their freedom to realise their institutional goals. Embodied, performative social practices, through structuration, hold together locations, situations, institutions and conjunctures, as well as the human inter-subjectivities that inhabit them.

The conjunctural is a distinct level of regulations and rules, dominated in developed societies by the legislative and organisational forms of the nation-state and, in Europe, by the supranational and intergovernmental forms of the European Union.

5.9 Context-awareness revisited

A context-aware computing, then, could be oriented in a number of ways. For example, it could be location-centred, as in the initial ubiquitous computing experiments, so that an enhanced sense of physical space and ambient physical parameters is achieved. Alternatively, context-aware computing could be situation-centred, focusing on the dimensions of embodied, situated, performative practice. Within situation-centred context-aware computing, it could be task-centred, helping someone to perform a specific task better or quicker; it could be role-centred, helping a person or a group negotiate their organisational roles better; it could be identity-centred, helping a person or a group sustain and develop better their sense of individual or group identity; or it could be centred on intersubjectivity, helping people to understand how to coordinate better the different institutional roles they are expected to play, such as mother, daughter, manager, campaigner, mentor, trainer, friend, etc., in order to develop appropriate behaviours and coping strategies. Context-aware computing could be institution-centred, focusing on the role-stresses that indicate a need for institutional reform. Alternatively, context-aware computing could be conjuncture-centred, focusing on helping a national society organise and change its institutions, their inter-relationships and its resource allocation among them, or helping international society articulate, understand and deal with its problems and tensions. Even more ambitiously, context-aware computing might enable the emergence of reflexive global community, encouraging a more deliberative approach to the tensions over resource use and allocation in a very unevenly developed global socio-economic system.

5.10 Conjuncture: repetition, reproduction, change and development

Conjunctures do not develop according to a single logic, but through the interplay of the specific logics or rationalities of particular social practices, working through the longer-running socio-historical spatio-temporal realities. These notions can be pursued through further consideration of 'Europe' in the post-Cold War, post-11 September 2001 conjuncture.

Europe, Rodrigues argues [46], is going through a transition towards a knowledge-based society. The traditional places, the encoded institutional/architectural/practical spaces, of the 20th century, such as the home, the factory, the office, the school, the street and the city centre, create strong expectations about the structure of activity (tasks and social practices) and the ensemble of roles and attributions. Those strong expectations often foreclosed options that are now opening up, in an era of technologies of continuous presence. However, those expectations made life simpler. Life is going to be more complicated henceforth, Agre [47] concludes (*contra* Weiser), and a central task for design, including the design of the devices for ubiquitous computing and ambient intelligent environments, will be to make sense of it.

The expectations associated with the traditional places made sense of the patterns of everyday interaction, of life style as a pattern of daily, weekly, monthly and annual cycles and intersecting patterns of routine and activity, a framework within which and against which one may act spontaneously. Expectations set

limits. They also made sense of interaction over the life course, for particular generations. Both of these sets of social and temporal expectations, concerning life style and life course, are undergoing change, or rather continue to undergo change, as they have done since the advent of industrialisation, urbanisation and societal and cultural modernisation in the 18th century. The familiar patterns, expectations, roles and ensembles prevailing in the latter half of the 20th century no longer suffice. Indeed, they were contested throughout that period, as manifested in the social movements that marked the era, for example focused on ethnic relations and civil rights, women and gender roles, decolonisation, ecology and the natural environment, sexual orientation, as well as the changing forms of the long-running class politics developed around proletarianisation, industrialisation and internationalisation.

Issues related to changing life styles and life course are already being discussed explicitly at the level of the European Union. In European Union countries, from different perspectives, both employers and employees are seeking more flexibility, and governments are seeking to mediate between these two kinds of flexibility to create a new European social model. For example, a report by the European Foundation for the Improvement of Living and Working Conditions (EFILWC) (http://www.eurofound.eu.int/) states that,

> "The traditional working life course in Europe is changing. Up to very recently, a standardised working life course existed for men. This included more than 40 years of continuous employment often with only one employer, and with distinct education and retirement phases. Learning, employment, and paid retirement after working were three sequential life phases."

As the report indicates, the working life course for women was somewhat different,

> "interrupted by longer periods of care and household work, leading either to a complete and permanent exit from the labour market or to continuous or discontinuous part-time work. Permanent full-time work for women was an exception and women retired earlier. In common with men, however, there were very separate periods of education and retirement." [48]

Since 2001, with encouragement from the European Commission's Director General for Employment and Social Affairs, a rethinking has been underway about the way in which periods of work, leisure, learning, and caring are distributed over the life course. Some employees are confronted with time stress. Many have difficulty marrying social and personal needs (care, lifelong learning, voluntary activities, unpaid housework) with demands from employers for more flexibility. At the same time, important groups of employees request greater flexibility in the workplace in order to gain more control over time use and their quality of life.

This double flexibility agenda, with demands for flexibility from both employers and employees, over the working life course creates an important challenge for both sides of the labour market. Employees are also confronted with a gap between more flexible working time and employment arrangements and traditional social security provisions, which are based on the standard male model of continuous working life course. This creates serious disadvantages for the flexible workforce and represents a policy challenge to modernise relevant social security provisions.

To respond efficiently to rapid economic and technological change, companies must adapt. Working time arrangements which improve the employability, productivity, and adaptability of the labour force play an increasingly important role in company strategy. Volatile markets have resulted in a demand for more flexible working time arrangements. At the same time, high investment costs have accelerated demand for working time arrangements which allow longer operating hours, resulting in an increase in unsocial working hours. Nonetheless, an increased labour supply, via better work-life balance or later retirement, is welcomed by employers, to avoid skill shortages and to control labour costs.

In general, by improving the feedback systems between natural ecosystems and socio-economic

ecosystems and within socio-economic systems, both of which imply institutional rearticulation, particularly of those institutions organised around the (new and more traditional) media technologies of mass communication, society as a whole (understood as a set of communities of different scales and organisation) might be turned towards more sustainable directions.

To be realised, these macro-social, potential and relatively abstract benefits (effectively at the level of socio-historical conjuncture) will have to be translated into concrete, situated social practices. It is therefore vital that a bottom-up or micro-social approach (focusing on the located, the situated and the communal, whether of place or of interest) balances a top-down, macro-social approach. The actual resolution of what transpires will depend on relative power and the lines of communication or dislocation within and between these two domains, the macro- and the micro-social.

A key issue in the translation of the potential into the actual is that of public acceptance and participation.

5.11 Developmental, critical and reflexive futures

Since ambient intelligence "is more a vision of the future than a reality" [49], it is appropriate to address it using the resources of futures studies, but of a critical variety, with its concern for how change occurs, the interplay of multiple factors, alternative futures, complexity and future-oriented learning, leading towards the kind of anticipatory action learning that may be necessary to engage in the design of ambient intelligent environments. [50]

As Punie indicates, the vision of ambient intelligence rests on technological progress in the fields of microelectronics, communication networks and interfaces, but it is also driven by socio-economic factors that go beyond the technological. Critical futures studies highlights the role of expectations in those socio-economic factors, articulated in rational discourses. In as far as critical futures studies deals with forecasts or predictions, it is to discuss how they relate to various forms of conventionalised or rationalised expectations, by arguing that an epistemology of forecasting or prediction is anchored in social epistemology. [51]

Critical futures studies recognizes the possibility of foresight, at the macro-social, communal and individual levels, but acknowledges the difficulty of achieving it, as well as the absence of guarantees that it has been achieved [52]. It also recognises the difficulties inherent in public administration-led national foresight exercises. [53]

Visioning is part of futures studies, as is examining the assumptions, expectations and justifications for what is envisioned, addressing the issues raised by, for example, Araya [54] in respect of what kind of social and technological visions ubiquitous computing and ambient intelligence represent.

In line with the focus on performative, embodied interaction, developed through the work of Agre, Dourish and Galloway, futures studies can accommodate questions that are epistemological, ontological, sociological, and technological at once through its concern with the dynamics of change.

Futures, prospective contexts, are a dimension of the process of contextualization which arises in and through performative, embodied interaction, and which can be easily neglected. Futures represent horizons towards which embodied, performative interactions, which are always in and of the present, are oriented. Futures studies makes explicit the directedness of performative, embodied interaction and the structures of expectations and rationalities by means of which that orientation is maintained, while also demonstrating that actual outcomes may be unintended and potentially absurd.

5.12 Futures, narratives, discourses

Through scenarios, futures studies can be used to explore narratives or logics of development or prospective achievement, for example as technological progress, societal modernisation and economic

growth, as a means for discussing complexity and critically examining the justifications being offered for specific changes.

Futures studies, applied to a recognition that contextualization arises through performative, embodied interaction, can be used to create an understanding of the different temporalities of locations, situations, institutions and conjunctures and the ways in which these different temporalities are intertwined. While it could be said that futures studies is marked by a concern for the long term, it may be more accurate to say that it is marked by a concern for temporalities, their plurality and their interrelationships, some of which are long term.

Finally, critical futures studies is marked by a concern for the subjective orientation towards the future. Subjective identities are sustained by narratives of self and by structures of expectations, by means of which the unknown and unknowable are made into terrains that can be traversed. Such identities, subjective orientations and narratives are negotiated and sustained through the embodied interactions of social practice, including those of language-based discursive practices. It is here that futures studies meets cultural studies, as such identities, narratives and patterns of intersubjective interaction are socio-cultural constructs, circulated by means of material cultural artefacts, which constitute enabling technologies and communication technologies.

For critical futures studies, ambient intelligence is a possible future for Europe, a socio-technical and environmental vision in which:

> "users are surrounded by intelligent interfaces supported by computing and technology everywhere, embedded in clothes, furniture, walls, vehicles, processes etc. The environment becomes aware of who – or what – is present and reacts accordingly. The whole body is used for interaction: speech, gestures and even direction of glances. In effect, the environment becomes the interface." [55]

The central question is what its realisation might involve.

6. Conclusion

Ubiquitous computing, ambient intelligence and context-aware computing are visions of prospective sociotechnical and environmental futures. The possibility, plausibility, probability and desirability of those visions need to be considered. This can only be achieved, as Weiser suggested, through an extended, collaborative, future-oriented, action learning cycle, the innovation process, elements of which are outlined above. [56]

Footnotes

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18. It would be all too easy for ubiquitous/pervasive computing and ambient intelligence to be seen as "an attempt at a violent technological penetration of everyday life", for "how else", argues Araya ("Questioning ubiquitous computing", available online at http://www.cc.gatech.edu/~keith/classes/ubicomplexity/pdfs/crit/araya-questioning-ubicomp.pdf.),

> "could we characterise a proposal that advocates the pervasive transformation of things into surveillable objects, the substitution of 'real world' situations by digital surrogates, and the transformation of our surroundings into responsive artefacts by massively populating them with micro-processors and related devices - all of these transformations being mainly driven by technology itself."

One of Araya's central complaints is that,

> "Ubiquitous Computing is conceived as being primarily... driven by technology, and its main sources of inspiration are other technologies that have successfully penetrated everyday life."

For Araya, the development of ubiquitous computing gives precedence to technology over human needs. Indeed, he argues that further development of ubiquitous computing could not be justified on the basis of its anticipation and satisfaction of human needs. He remarks acerbically,

> "What is striking about most of these scenarios [in which an everyday activity is unobtrusively enhanced by forms of ubiquitous computing] is the marginal character of the needs referred to in them and of the envisioned enhancements of the activities."

He cites as examples such marginal enhancements as elevators stopping at the right floor, rooms greeting people by name, and secretaries knowing instantly the location of employees.

"Even more striking", Araya continues,

> "is the stark contrast between the marginality of the enhancements and the complexity of the computing infrastructure required to achieve them".

For Araya, implementation of ubiquitous computing would render the world more uniform and homogeneous, obliterating what is distinct about the places in which we live and eradicating the otherness of certain aspects of the world, the differences which make the world come alive for us in our senses. In this view, it is extremely doubtful that ubiquitous computing could thereby enhance the world, as is often claimed.

Araya points to the self-serving nature of some of the justifications being used as reasons for developing ubiquitous computing. For example, the Chief Technology Officer of the Intel, Patrick Gelsinger, has outlined a grand vision for the company. He is quoted as saying that,

> "Before I retire from Intel, I want a piece of Intel technology touching every human on earth, every minute of the day, in every aspect of their lifestyle."

The motivation is not primarily concern for enhancing the environment of "every human on earth", although some unspecified benefit for them is assumed, but the need to move into markets other than the personal computer arena, where growth rates have slowed and markets, at least in the most developed countries, may be saturated. Intel will have to look elsewhere if it is to continue to grow and expand, for example by moving towards wireless communications technology and by designing products for the digital home.

However, as the example of electricity a century before shows, while it is important to be conscious of potential negative consequences, it is equally important not to prejudge the issues involved. At the end of the 19th century, the electrification of private life and the mechanisation of the household were important issues. Electricity was being represented as the fuel of the future, as a liberating technology promising a clear, clean, healthy and efficient way of life. Such discourse served the purposes of an industry that was looking for ways to use the electricity network outside working hours, in the home environment. Although self-serving at the time, and perhaps not capable of delivering all that was promised, electrification of the home has proved of immense benefit in the long run. Similar discourses surrounded the introduction of the telegraph, the telephone, radio, television and videotext. (Punie, Y. (2003). *A social and technological view of ambient intelligence in everyday life: what bends the trend?* Available online at http://www.lse.ac.uk/collections/EMTEL.

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