Encountering The World With Ubiquitous Computing

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Originally presented at ETHICOMP 1995

Abstract

Ubiquitous Computing has been proposed as a long term strategy for the penetration of everyday life as a whole with computing and communications technology. What are the possible effects of this proposed massive deployment of technology upon things, environments, and people? To address these complex questions we first develop an ontological perspective from which we can examine our involvement with things and tools, and identify a fundamental ontological dimension of such involvement, namely, "otherness," which will play a crucial role in the analysis. From this ontological perspective, we examine scenarios illustrating possible applications of Ubiquitous Computing and determine potential transformations on the ontological structures of things, living beings, and environments. Subsequently, by elaborating on the transformed nature of our involvement with these new kinds of beings, we determine how they would appear to us and, by extension, how we would encounter a world intensely penetrated with Ubiquitous Computing.

Introduction

After half a century of unabated development computing and communication technologies have become impressively powerful, as evidenced both by achievements such as the Internet and the World Wide Web and by the striking character of emerging technologies such as Virtual Reality, Neural Networks, and Robotics. In addition, computing and communication technologies are becoming increasingly ubiquitous being routinely used in a variety of activities. As the power and ubiquity of these technologies increase, the many-sided transformations induced by them correspondingly grow in importance and scope. It then becomes an urgent task to attempt to determine the nature of these possible transformations.

Ubiquitous Computing has been proposed as a long term strategy for the penetration of everyday life as a whole with computing technology [Weiser, 1991, 1993; Weiser and Brown, 1997]. It proposes a new way of integrating multiple technologies beyond the paradigm of the unembedded computer in a way conducive to their pervasive utilization in everyday activities. Ubiquitous Computing aims at penetrating "everything" with micro-processors, sensors and transmitters, thus making it possible the real-time dissemination of information from everywhere to everywhere, which in turn would enable the development of a variety of innovative applications. What makes Ubiquitous Computing unique among related technological proposals is the massive character of the proposed deployment and the range of human activities that would fall within its reach.

What are the possible effects of this proposed massive deployment of technology upon things, environments, and, consequently, on ourselves, future users of the technology? We believe that to be able to achieve an appropriate understanding of the social and ethical issues arising from such deployment, it is necessary to first develop a clear understanding of how things and environments would be transformed by this technology, as well as an understanding of how our involvement with them would be consequently transformed.

Our task, then, is twofold. First, we must develop the basic elements of a theoretical perspective from which we can address the issues of interest. Second, we need to analyze the proposals for Ubiquitous Computing from the previously developed perspective. After examining the principles underlying this technology, we focus on several scenarios illustrating possible applications of Ubiquitous Computing and determine potential transformations on the ontological structure of things, living beings, and environments. Subsequently, by elaborating on the transformed nature of our involvement with these new kinds of beings, we are able to identify how they would appear to us and, by extension, how we would encounter a world intensely penetrated with Ubiquitous Computing. This article extends the analysis of Ubiquitous Computing initiated in [Araya, 1995] and complements related analyses of technologies such as Virtual Reality and Interactive Learning Environments presented in [Araya, 1996 and 1997].

Approach and Method

While engaged in activities, people use tools to perform tasks. Technological innovation "improves the performance" of existing activities by modifying existing tools or by introducing new ones, or creates new kinds of activities, possibly supported by entirely new kinds of tools.

It is tempting to assume that changes affecting tools and activities are "external" to human beings. After all, it is common observation that once people use tools, they leave them behind, such that whatever change that may have taken place in the "nature" of such tools cannot really reach their users. But, is this truly the case? What is the nature of the relationships between human beings and the activities and tools with which they engage in? Is it the case that on one side there are human beings, on the other side there are activities and tools, such that the two sides come periodically together to part ways again? Or, is it rather that human beings, activities, and tools are thoroughly entangled to the point that human beings cannot be understood separately from them? Such is the view explored by Heidegger in Being and Time [Heidegger, 1996], and crystallized in the notion that human beings are fundamentally characterized by the structure of "being in the world."

World must be understood here as a totality constituted by complexes of useful things and tools, in whose context activities involving the use of these things and tools take place [Heidegger, 1996, e.g., p. 70]. Being in the world is a being absorbed in a practical, non-theoretical sense in the carrying out of an activity [Heidegger, 1996, e.g., p. 71]. Because human beings are fundamentally characterized by the structure of "being in the world," they cannot be properly understood apart from their involvement in activities. In addition, the structure of the totality that constitutes a "world," structure which consists of the multiple relationships that obtain among the complexes of things and tools, constitutes a background of relationships on whose basis human beings make sense of the situations in which they are involved. "Being in the world," then, also has the connotation of being grounded in this encompassing network of relationships that provides a background from which we understand [Dreyfus, 1991, e.g., pp. 61, 97]. Given these entanglements between human beings, things, and activities, what kinds of effects could take place due to technological change? Although each of the mentioned elements could be affected by technological innovation, in anticipation of the subsequent analysis of Ubiquitous Computing we will concentrate primarily on effects both on things and on the involvement people have with them, and will pursue these issues only to the extent needed by such analysis.

We can get involved with things in a variety of ways. Consider the case of eyeglasses. We can use them while reading, search for them if misplaced, try to fix them if needed, and, perhaps, think of better kinds of glasses if we find them wanting. When using a thing we have a direct bodily involvement with it; when searching for it, our involvement is more distant, in "time" and "space." Through this involvement, things appear to us in certain ways. If because of technological change, things change - the eyeglasses are replaced by contact lenses that we directly insert in our eyes - our involvement with them also changes, and in consequence things may appear to us differently.

Thus, to identify effects of technological innovation on things we need to examine both how they have been transformed by technology as well as how our involvement with them has changed. To identify effects on us, users of things, we need to examine our

changed involvement with them, and how through this transformed involvement things appear differently to us. We are confronted with a unitary phenomena which we must examine from different angles.

Given that our engagements with things can be very complex, what kinds of phenomena do we look for in such changed engagements? At least two elements need to be taken into account, namely, the specific characteristics of the technology that induces the changes, and the particular perspective from which we are carrying out the analysis. Considering that, as will be described in the next section, Ubiquitous Computing attempts to embed computing technology into every-thing, thus potentially altering our involvement with them; and that we are concerned with deep effects of technologies on things, on how they appear to us, and on how we encounter the world with them, our analysis will concentrate on particular ontological phenomena.

As Ubiquitous Computing purports to modify the things and tools themselves, we need to examine whether these changes could imply transformations in the "ways of being" of these things and tools, namely, on their ontological make up. Similarly, because changes in their ways of being could bring changes on the ways of being of our involvement with them, and, possibly, on the fundamental ways in which we encounter the world while using them, we need to concentrate on what Heidegger refers to as fundamental ontological phenomena [Heidegger, 1996, e.g., pp. 11 and 33]. These are phenomena that characterize the ways of being of human beings, in particular, their "being in the world."

In any involvement with a thing, which takes place in the context of a world and a particular activity, there is an encounter between two beings, that is, the thing and "who" is involved with it. For one of these beings, us, implicitly or explicitly the other appears as an "other." This appearance as an "other," which may seem to be a rather amorphous and insignificant phenomena, is, nonetheless, something; in particular, it is a way in which a fundamental ontological dimension reveals itself to us. We call this ontological dimension otherness.

We say that otherness is a dimension because it is constituted by manifold, interrelated phenomena which come into play when we encounter a thing. These phenomena may refer primarily either to the things that we encounter or to our involvement with them during an encounter. Thus, we say that things are independent and separate from us, and because of this separateness, they may become inaccessible to us. We also say that they are unique, different from other things.

Depending on our involvement with things, different ingredients of otherness may come to the fore. When a thing becomes lost, that is, when we need it in the context of an activity but it is not immediately available or we do not find it where expected, the inaccessibility of the thing as an ever present possibility manifests itself openly. A typical way of handling such impasse is to suspend our current activity immersing ourselves in another, in which we search for the missing thing. Now, other aspects of

otherness may manifest themselves, such as the separateness and independence of the thing. The analysis of Ubiquitous Computing subsequently developed will show that it is precisely within this dimension of "otherness" that important effects of this technology are to take place.

Our task now is to examine the technology of Ubiquitous Computing by focusing on two related questions. First, How could Ubiquitous Computing affect and transform the things, tools, and, even, living beings we deal with in the performance of activities? And second, How could Ubiquitous Computing affect our involvement with these things and tools and, in consequence, the way they appear to us? To approach the first question we will analyze the technological infrastructure and scenarios presented in the proposals for Ubiquitous Computing. To deal with the second question, we will extend the first analysis by taking into account the fundamental principles underlying the proposals.

Ubiquitous Computing

Although computing technology is becoming increasingly ubiquitous, can such technology, as it has developed so far, achieve maximal penetration of everyday life? This is the central question that the proposals for Ubiquitous Computing address [Weiser, 1991, 1993; Weiser and Brown, 1997].

Several key principles underlie the proposals. First, Ubiquitous Computing aims at achieving maximal ubiquity. Such principle, responsible for the surprising character of the proposed technology, calls for the penetration of everything with computing technology. Computers "will be embedded in walls, chairs, clothing, light switches, cars - in everything" [Weiser and Brown, 1997, p. 77]. Second, such ubiquity would make it possible the real-time dissemination of information from everywhere to everywhere. This principle, which we will call the ultra-disseminability of information, by making information available everywhere would enable the development of a myriad of innovative applications, thus "making everything faster and easier to do, with less strain and fewer mental gymnastics" [Weiser, 1991, p. 104, our emphasis]. Third, to achieve ultra-disseminability an appropriate technological infrastructure is required, guided by the principle of ultra-connectivity: everything is physically connected to the web of computing. Ubiquitous Computing "is fundamentally characterized by the connection of things in the world with computation. This will take place at many scales, including the microscopic" [Weiser and Brown, 1997, p. 77].

Such principles, sweeping as they are, do not yet take into account significant barriers that may prevent the penetration of everyday life with computing technology. The current emphasis on personal computers and laptop machines leads to a situation in

which computing is not "an integral, invisible part of people's lives" [Weiser, 1991, p. 94], but one in which the computer remains in the foreground, possibly interfering with aspects of the activities in which it is being used. We arrive then at the fourth principle, based on "a new way of thinking about computers, one that takes into account the human world and allows the computers themselves to vanish into the background" [Weiser, 1991, p. 94], namely, the principle of disappearance into the background.

There are two interrelated but distinct aspects associated with this principle. First, there is the notion that to decrease interference computing technology should "move easily from the periphery of our attention, to the center, and back" [Weiser and Brown, 1997, p. 80]. When a tool is no longer needed, it should smoothly recede into the periphery, thus decreasing information overload, but it should effortlessly slide back into the center when needed. Second, there is the notion that to be truly invisible, computing technology should become "part of life," as is the case of "profound" technologies, such as writing and electricity. Profound technologies are such because they "weave themselves into the fabric of everyday life until they are indistinguishable from it" [Weiser, 1991, p. 94].

In this second sense, the notion of background referred to in this principle is related to the notion of background we examined in the previous section. Technologies alter the world which we inhabit. When a technology is no longer salient but becomes part of everyday life and we take it "for granted," it has become part of the background. Becoming part of the background means that the network of relationships that constitutes such background, on the basis of which we make sense of situations and circumstances, now incorporates the relationships brought about by the new technology. In consequence, our way of making sense includes these new relationships, thus leading to new kinds of understandings.

How could this disappearance into the background and periphery be accomplished? It is proposed to remove the computer as a focal point of interaction by embedding computing technology "into the world at large." This can be accomplished by exploding the computer into manifold pieces, each of them capable of specific functionalities, and by inserting these pieces at appropriate points in the world. The task now becomes one of identifying the right pieces, inserting them in the right way at the right places, and reconstituting the whole using communication technologies.

Taken together, the four principles we have identified, namely, maximal ubiquity, ultra-disseminability, ultra-connectivity, and disappearance into the background, are the cornerstones of Ubiquitous Computing as a long term strategy for the development of computing technology.

We now briefly consider the technological infrastructure required by Ubiquitous Computing. Computing and communications devices are pervasively embedded in all kinds of things and environments - such as offices, homes, schools, cars, and highways - to support all kinds of activities. People are constantly interacting with hundreds of

computing devices interconnected via wireless networks [Weiser, 1993, p. 75]. To be able to constantly interface with the web of computing, displays of varying sizes and shapes are embedded everywhere. To gather, process, and disseminate information, as well as to perform actions, signal emitters, micro-processors, and actuators are pervasively embedded in things and buildings. Networks of sensors distributed throughout environments capture the signals and disseminate them through wired and wireless networks.

Ubiquitous Computing is an "enabling" technology, making it possible the development of multiple applications, which ultimately are the technologies that would alter the way we live. To provide vivid images of the possibilities opened up by Ubiquitous Computing, the proposals describe a variety of scenarios [Weiser, 1991 and 1993]. We begin the analysis by examining three scenarios, each of which includes a general description followed by concrete examples.

What Things Become with Ubiquitous Computing

First Scenario: Electronic Badges and Tags

Let us consider the following scenario.

People and things of all kinds have attached or embedded signal emitters, which are monitored by networks of sensors. Their identities and locations are constantly available in the web of ubiquitous computing. For example, to locate a misplaced pair of eyeglasses one accesses the web, furnishes a description, and without much delay receives information about its location, possibly at the office, or in the glove compartment of the car, or even in the overhead compartments of an airplane.

In these scenario, because things and their locations are being constantly monitored, in a very real sense things can no longer become lost. But what it is for a thing to be lost? In the context of an activity we discover that a useful thing, say a pair of eyeglasses, is missing. We thought we had left it on the table near the book, but it is not there. This surprises us. Because we need it, we inspect the surrounding environment but the thing does not appear. Unless it was taken without our knowledge it must be somewhere within our reach, so we search for it by inspecting other places. Suddenly, in a totally unexpected place, we encounter the thing. Humble as it may be, there it is, in front of us, "shining" in its presence. Such sudden re-encounter also surprises us.

What has happened between the thing and us when it got lost? This event has again made manifest to us a fundamental characteristic of the thing, as a thing, not just as a pair of glasses: that the thing is an other than us. Both, when we realize that the thing is lost as well as when we re-encounter it, we have a sharpened awareness of its otherness, manifested by the "surprise" that accompanies these events.

When a thing becomes lost, several aspects of its otherness become apparent to us, although not necessarily in an explicit way. In its being lost, what is disrupted is the possibility of our mutual encounter with the thing. Although we come to the encounter, it does not show up! Thus, the thing reveals to us the possibility of its inaccessibility. Somehow, a gap has become wide open between the thing and us, uncovering a "distance." Because of such distance the thing is no longer accessible to us, and its separateness from us comes to the fore. Separateness refers here to a fundamental character of things by which they constitute a unity in themselves, distinct from us, with a permanence, unity which makes them to be other than us. It is precisely because of such separateness that a distance can interpose itself between the thing and us.

As a being that is separate, apart from us, the lost thing may also show its independence from us. The thing is "in-de-pendent" in the sense that it is not like a "pendant," something that we carry along hanging from us at all times. In its being lost we clearly see that such is not the case. In this sense, then, the thing does not depend on us. On the contrary, it is us who depend on the thing, which is precisely why we became aware of its being lost in the first place: we needed it, but it was not there.

What happens then, when signal emitters are embedded into things and networks of signal detectors are ubiquitously deployed throughout environments? Because through the web of computing we can determine the location of a thing at any time, its possibility of being inaccessible to us has been significantly eroded. Whenever we need the thing, the web gives us its location. If by a malfunctioning of the web we cannot locate the thing and it indeed becomes lost, such occurrence would take on the character of an exception. In addition, a displacement has taken place. The particular thing with the embedded tag can no longer become inaccessible by itself; rather, it does so only because something else, the web, has malfunctioned.

Indeed, a fundamental character of the thing, its separateness from us, has been notably affected, given that with the touch of a button we can bridge the distance that separates us from the thing. Although we cannot yet act upon the thing at a distance, as subsequent scenarios will show, we can always know of its whereabouts. Insofar as through the web we keep constant vigilance over the thing, its independence has also been eroded. In fact, our bodies and the body of the thing have become invisibly connected through the wireless networks. By intervening the thing with technological insertions we have captured it within the surveillance mechanisms, thus establishing a physical link. Through this physical link we carry the thing like a pendant.

As a consequence of the above, we can say that in the new situation fundamental characteristics constitutive of the otherness of the thing, including its inaccessibility, separateness, and independence, have been notoriously eroded. The thing has now become a "thing under surveillance."

So far, a simple and rather insignificant event has taken place: a humble thing - a pair of glasses - can no longer become lost. Yet, if we now take into account the principle of maximal ubiquity, a fundamental principle of the proposed technology, we see that our scenario has to be substantially enlarged such that everything, possibly including living beings and human beings, would undergo this transformation from things into "things under surveillance."

Second Scenario: Embedded Sensors and Actuators

Let us now consider the following scenario, which we composed by extending and combining parts of scenarios described in the proposals. Although the proposals never refer to actuators in living beings as in this scenario, they do refer to actuators embedded throughout environments. The principle of maximal ubiquity justifies our extensions.

Things, living beings, and possibly human beings, in addition to electronic tags have embedded sensors to gather state information and actuators to change their state. Pervasive networks of sensors receive this information and relay it to communication networks, which disseminate it and deliver commands to the actuators. For example, trees and entire forests have been penetrated with signal emitters, sensors, actuators, and micro-processors. Throughout the forest, networks of sensors gather information for the web of computing, which comes back with commands for the actuators.

In this scenario, trees in a forest have been reached by the expansion waves of Ubiquitous Computing. At first, because the required technology would not be very advanced, perhaps only sensing devices and signal emitters would be embedded in the trees, while networks of sensors would be laid down throughout the forest. Subsequently, micro-processors and actuators would also be embedded. Using state information transmitted via networks, appropriate actions, possibly leading to "enhancements" in the trees' vital processes, are computed and relayed to the actuators.

What has happened to the trees and the forest after these events? With the embedding of sensors, actuators, and micro-processors, the boundaries of trees have been cracked open. Such boundaries, delimiting the "body" of a tree from its surroundings, have become unstable and open to additional technological penetration. Thus, a basic

ontological characteristic of a tree, which we will call the self-containment of the tree within its own boundaries, has been substantially eroded. In addition, the vital processes that sustain the tree as a living being have been interfered with, possibly in a substantial way, with the introduction of actuators. As a result, the character of the tree as an autonomous living being has been significantly curtailed.

Prior to this technological penetration, the current state of the tree was protected from being constantly known by the distance that separated it from the organization or system, while its identity was safeguarded by the anonymity provided by the surrounding trees in the forest. But once identity, location, and state information about the tree are being constantly disseminated through the web of computing, the anonymity of the tree has been liquidated. From being an entity on its own, intimately rooted in the earth, the tree - and, by extension, the forest as a whole - has now physically become part of an encompassing organization. More specifically, the tree has become linked with a tight feedback loop that, feeding from sensed state information, feeds back, via actuators, controlling actions on the tree. Thus, it is no longer clear where the system ends and where the tree begins. Possibly, key characteristics of its living processes are now being determined and carried out through the web of computing. In consequence, the separateness and independence of the tree have been curtailed to an unprecedented degree.

If all these alterations of basic ontological characteristics of the tree are taken together, they amount to a significant transformation of what the tree is. Such a tree has become physically part of an all encompassing framework enabled by Ubiquitous Computing technology, with the consequence that central characteristics of its otherness, such as its self-containment within its own boundaries, living autonomy, anonymity, separateness, and independence have been altogether liquidated or seriously eroded. As a consequence, the tree has been profoundly transformed becoming an "enframed tree."

Third Scenario: Tele-Environments

Let us now briefly examine a third scenario:

Environment information, including states of things, text, as well as sound and video representations, are available in the web of computing. Appropriate integration and display of such information gives rise to highly portable tele-environments. Things can be remotely manipulated through tele-commands. For example, fully portable offices allow access and use from anywhere, at any time. Home appliances, furniture, and things in general are remotely inspectable and manipulable.

Once sensors, micro-processors, and actuators have been embedded into things and living beings, entire environments such as offices, building, houses, and cars can be made available in the web of ubiquitous computing, thus becoming under surveillance and enframed. A tele-environment is obtained by "mapping" an environment into a computational surrogate that preserves some of the useful properties of the "original." Video and sound plus sensor information make it possible the creation of integrated functional views of any environment, in which tele-manipulation through actuators is possible. Summarily, once an environment has become a tele-environment, basic ingredients of its otherness such as the rootedness of an environment in its place, its corporeity, separateness, and uniqueness have been significantly eroded or simply liquidated.

How Things Would Appear to Us

We now raise the question of how things would appear to us, once the technology of Ubiquitous Computing has massively penetrated everyday life along the lines illustrated by the previous scenarios. In the first scenario this question becomes: Would things continue to appear as "things," which just happen to be under surveillance ("things under surveillance"), or would they appear in a significantly different way, that is, as "things-under-surveillance"? And, what is a "thing-under-surveillance," anyway? We do not have the means to provide a definite answer to these questions, but we believe that the stakes involved in such a massive and invasive deployment of technology are sufficiently important that we must make an effort to identify possible directions the answers to such questions could take. We will proceed by considering the results of our previous analysis in the light of the principles of Ubiquitous Computing.

In one of its senses, the principle of the disappearance of technology into the background stipulates that in order to achieve maximal ubiquity without interfering with the performance of activities, the technology should evolve in such a way as to become virtually invisible. In the current scenario, this would mean that the tags attached to things and the networks of sensors monitoring them would be literally invisible to us. Even if total invisibility were technologically infeasible, if the tags were properly weaved into the thing in such a way that interference with its use would be minimal, they would eventually disappear into the background, thus becoming effectively invisible to us. In such a case, in dealing with a thing we would not normally be aware of whether it was a "thing" or a "thing under surveillance."

In addition, as the technology becomes increasingly pervasive it is likely that many, perhaps most things would become "things under surveillance," containing embedded

tags and being monitored by networks of sensors. In consequence, it appears likely that because of invisibility and pervasiveness we would tend to take most things as being "under surveillance," even if in reality some of them were not. Thus, a shift would occur such that by default, so to speak, we take things as being under surveillance. In this transformation due to invisibility and pervasiveness, then, we take for granted that things are under surveillance.

How would our involvement with things change? Although because of the invisibility of the technology our direct bodily involvement with things while using them would tend to remain unchanged, other kinds of engagements would be affected. Thus, we no longer need to search for a thing that is not at hand when needed. Instead, we now access the ubiquitous web of computing and its location becomes immediately known to us. It is even possible, in the current scenario, that whenever we need a thing that is not directly at hand we would immediately access the ubiquitous web of computing to determine its location, so that many of our direct engagements with things would be preceded by a corresponding engagement with the web.

We are dealing then with a new kind of being, one which, although sharing many characteristics with a "thing," differs significantly from it because, as we noted above, it has been deprived of fundamental aspects of its otherness, including inaccessibility, separateness, and independence. An almost invisible, over-reaching apparatus, the web of ubiquitous computing, keeps a constant eye on the thing - on every thing. Having virtually bridged the distance that separated it from us, we virtually carry the thing like a "pendant." What we gain in accessibility the thing loses in otherness, and we find ourselves involved with something that is "less other" than it was before, something that offers us less opportunities for becoming aware of its otherness. In this transformation due to our changed involvement with them, the thing is now less of a thing than what it used to be. In fact, it is no longer a thing, it has become a "thing-under-surveillance."

If we now turn to the other scenarios examined in the previous section, we find similar kinds of effects, although greatly intensified. These scenarios portrait an increasingly powerful deployment of Ubiquitous Computing technology, possibly leading to enframed things and living beings, as well as to environments which have become virtualized. Fundamental characteristics of the otherness of living beings - such as their self-containment, autonomous living, and anonymity, as well as of entire environments - such as their rootedness, corporeity, separateness, and uniqueness - would have been substantially eroded. Thus, in our "being in the world" we would be absorbed with things and environments that have been deprived of significant aspects of their otherness.

Overall Character of Potential Effects

In the light of the previous analysis, we can characterize a significant kind of potential effect of Ubiquitous Computing on things, and on how they would appear to us, as a systematic dismantling of the otherness of things and environments by computational means. Such a dismantling is achieved by deploying a pervasive, all-encompassing computational apparatus that would mediate our involvement with those things and environments. In fairness, it must be said that the elicitation of such effects is by no means exclusive to Ubiquitous Computing. In fact, modern technology, of which Ubiquitous Computing is a particular expression, in many ways produces related kinds of effects (see [Heidegger, 1977]). What is peculiar to Ubiquitous Computing, though, is the intensity and pervasiveness with which such dismantling is pursued. Analyses of other computing technologies uncover related effects [Araya, 1996, 1997].

Let us briefly consider now the following fundamental question: To what extent can Ubiquitous Computing contribute to transform the way the world appears to us in a fundamental way? Such a possibility is implicit in the principle of "disappearance into the background." As stated in [Weiser, 1991, p. 94], "the most profound technologies are those that disappear." Disappearing means that the technology has become part of the multiple relationships or ground out of which we make sense of situations. If, as in one of the scenarios, things appear to us as "things-under-surveillance," after the disappearance of such technology into the background, this would no longer surprise us. And it is precisely at such moment that we can truly say that things have become for us "things-under-surveillance," when that circumstance would have become utterly unsurprising to us. Such a total transformation, to the point of being unsurprising, of what things are for us, would imply that the way the world appears to us would indeed have significantly changed.

Final Remarks

What is the validity of the analysis we have developed in this work? First, our characterization of potential effects of Ubiquitous Computing on things and environments can be directly traced to the technological infrastructure and scenarios described in the proposals, and is the result of examining such scenarios from an ontological perspective. Second, the analysis of how things would appear to us as a result of our changed involvement with them is more speculative in nature, and was based on the application of principles of Ubiquitous Computing to those same scenarios to determine the scope of the possible transformations. The speculative character of this part of the analysis mirrors the speculative character of the proposals which purport to provide a long term view of the future of computing. Overall, then, these analyses

provide us with insights into possible effects to be expected from the pervasive deployment of Ubiquitous Computing.

It should be noted that, although not carried out from an explicitly ontological perspective, Borgmann's analysis of the effects of modern technology on things [Borgmann, 1984], in terms of the "device paradigm," constitutes a significant effort in a related direction. Ihde's phenomenological and hermeneutical analyses of technology also represent related avenues of work [Ihde, 1979, 1983 and 1990].

Ubiquitous Computing is a deeply ambiguous technology. While the proposals suggest that this technology will open up many new possibilities thus "invisibly enhancing the world that already exists" [Weiser, 1991, p. 94], the analysis presented here suggests that such enhancements would take place at the expense of the erosion of the otherness of things. It is tempting to think that we can dismiss these concerns with a mere shrug. We believe that such response would not be responsible. "Forgetting" the otherness of things and environments is to forget that there is something beyond humans and beyond the increasingly human-constructed world which we inhabit. Forgetting the other than human is tantamount to a violent reduction of the world to the very finite dimensions of human beings.

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