Ambient Intelligence in cloud Computing

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ABSTRACT

Ambient Intelligence builds on three recent key technologies: Ubiquitous Computing, Ubiquitous Communication and Intelligent User Interfaces – some of these concepts are barely a decade old and this reflects on the focus of current implementations of AmI. Interactive systems have been the dominant computing paradigm over recent years. This paradigm is characterized by the fact that human user and the system communicate and interact explicitly using different modalities. However to come closer to visions of Ambient Intelligence, Calm Computing, Disappearing Computing, and Ubiquitous Computing new forms of interaction are required. Observing humans interacting with each other and new possibilities given by emerging technologies indicate that a new interaction model is needed. In this chapter we present the concept of implicit human computer interaction (iHCI) that takes the users context into account when creating new user interfaces for ambient intelligence. Beyond the model examples are given, application areas are described and basic implementation issues are discussed. Our research leads to a more general discussion on disappearing and invisible user interfaces. In the invisibility dilemma we explain that in many application areas there may be an inherent conflict. The transparent user interface and the added value gained by introducing technology are often opposing goals, especially combined with users that are creative in appropriating their tools.

Keyword: - *Ambient Intelligent, Cloud Computing, Ubiquitous Computing.*

1. Introduction

The objective of AmI is to broaden the interaction between human beings and digital information technology through the usage of ubiquitous computing devices. Conventional computing primarily involves user interfaces (UIs) such as keyboard, mouse, and visual display unit; while the large amount of ambient space that encompasses the user is not utilized as it could be. AmI on the other hand uses this space in the form of, for example, shape, movement, scent and sound recognition or output. Sensors would adapt to a homeowner through sound, scent, shape, and movement. These information media become possible through new types of interfaces and will allow for drastically simplified and more intuitive use of devices. For the communication between the latter, wireless networks will be the dominant technology. The combination of simplified use of devices and their ability to communicate eventually results in increased efficiency for the users and, therefore, creates value, leading to a higher degree of ubiquity of computing devices. Examples of such devices range from common items such as pens, watches, and household appliances to sophisticated computers and production equipment. The purpose of this chapter is to give an basic overview of the technological challenges behind the concept of AmI.

2. Ubiquitous computing and communication

Ubiquitous computing can be defined as the use of computers everywhere. Computers are made available by means of the physical environment, but in an invisible way for the user. Several computers are embedded in the environment, and available to each person that is present there. Each computer can perform the tasks for which it is prepared with little human intervention or even without requiring that the user detects its presence. The idea of ubiquitous computing was first thought by Mark Weiser in 1998 at the Computer Science Lab at Xerox PARC [1]. He envisioned computers embedded in walls, in tabletops, and in everyday objects. A person might interact with hundreds of computers at a time, each invisibly embedded in the environment and wirelessly communicating with each other [2]. William Buxton states that ubiquitous computing is characterized by two main attributes[3]

• **Ubiquity:** Interactions are not channeled through a single workstation. Access to computation is “everywhere”. For example, in one’s office there would be dozens of computers, displays, etc., ranging from watch sized Tabs, through notebook sized Pads, to whiteboard sized Boards. All would be networked. Wireless networks would be widely available to support mobile and remote access.

• **Transparency:** This technology is non intrusive and is as invisible and as integrated into the general ecology of the home or work place as, for example, a desk, chair or book.

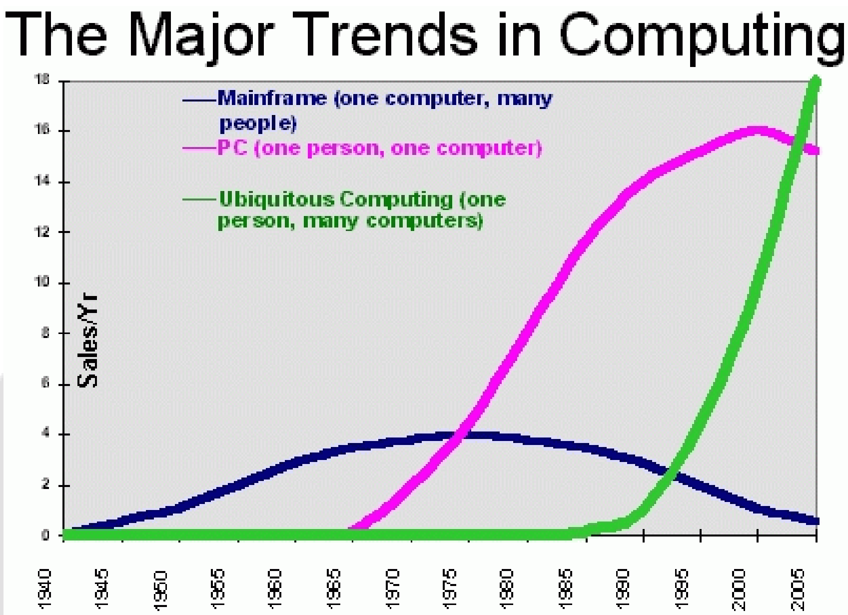

Fig -1 The major trend in computing

We are now in a time in which computers are commonly used, but they demand a high attention from the users. Using ubiquitous computing, people will not be aware of the presence of computers, they will be in the background such as it has happened with other common uses of technology: motors, electricity, Ubiquitous computing devices are not personal computers as we usually think of, but very tiny devices, either mobile or embedded in almost any type of object: tools, clothing, furniture, cars… communicating through increasingly interconnected networks.

3. Technical Features

There are several technical features that must have an ubiquitous computing system.

3.1 Terminal and user interface issues

The devices that are used should have a good display quality and responsiveness to user input. Even with limited display sizes, the use should be as intuitive and clear as possible, and different means of data input can be used such as pens, handwriting recognition or speech recognition.

3.2 Low cost devices

If we are developing a system with many computers for only one person, each computer has to be low in cost in order to be feasible. Although general purpose computers are more expensive, the kind of computers that will be used for ubiquitous computing do not need this. They will be more specific computers for concrete applications, so they will not have the processor and hard disk requirements that general purpose computers have.

3.3 High bandwidth

Another requirement for ubiquitous computing is to have enough network bandwidth to allow that the communication between the different devices that are used. Besides, it is not only required to build a high-bandwidth network that is capable of communicating with the different terminals, but there are also many issues related to the current state of the system: establishing the locations of mobile terminals (if they are used), making the best use of the available frequencies, maintaining the quality of services, encrypting data, eliminating network latency…

3.4 'Invisible' file systems

When a user starts to use a computer, he / she has to learn some basic aspects about the operating system and the concepts of files and directory structures. That makes the user focus in the way how information is stored instead of the information itself. One of the requirements of ubiquitous computing is that computers should become invisible, and they should be able to understand the user in his / her own terms, for example, using voice recognition or other intuitive interfaces. Users should be able to access to data without knowing specific file names, location or format.

3.5 Automatic installation

Ubiquitous computing should eliminate the need for program installation. In current systems, most programs need to be installed, and that can be a source of problems and, in any case, it requires the active intervention of the user. The concept of installation has no sense in ubiquitous computing. Programs should be able to move from a computer to another without requiring that each computer makes fundamental changes to its own configuration in order to run the new program. Some technical alternatives are the use of programming languages as Java, that are platform-independent and are moved easily from one computer to another.

3.6 Personalize information

It would be good that an ubiquitous computing system can personalize the information that presents depending on the user. In order to do that, one approach can be that every time a new person joins a community her/his personal profile needs to be added to every device.

3.7 Privacy issues

One of the most important problems of ubiquitous computing is that it can generate serious privacy risks. The system can record the actions of the users, their preferences, their locations… And some other people may access to these data. New network technologies such as infrared or wireless radio communication use encryption to ensure security, but that is against the limited bandwidth of these technologies.

3.8 Devices

In ubiquitous computing research, different technological approaches are used, such as PDAs, other mobile devices, machines like TV… All these different devices are combined to set up prototypes for the demonstration of ubiquitous computing scenarios. The trend is that we are moving away from the traditional desktop computing paradigm. Computational services are becoming mobile, as well as user do. Two approaches can be used:

- To provide the user with mobile devices
- To distribute different devices in the environment.

In any case, current services need to be extended to take advantage of the constantly changing context.

The ideal scenario for an ubiquitous computing system includes a real-time tracking mechanism that can calculate the location of the different components of the system. The system will also track the current state of each component and, inside this context, it will deliver messages and interact with the user in an intelligent way. Users will be able to select between different devices in order to have access to data resources that can be stored in any location on the network. Devices should be intuitive and adapt their behavior to suit the current user and context. When designing an ubiquitous computing scenario, the usual procedure is to examine the target space, pick a set of locations where information is most likely to be needed, and then install display devices at those locations. As a sample application, we can point out an ubiquitous computing system in a living room. Different capabilities have to be provided [5]

- Ubiquitous display of information on planar surfaces: floor, ceiling, walls, furniture, interior sides of furniture
- Ubiquitous audio
- Ubiquitous interaction with information on most planar surfaces

4. Technical Devices

There are different technical devices that can be used for mounting the ubiquitous computing system. We are going to describe them shortly in the following points.

4.1 Wireless devices

Handheld devices like PDAs or mobile phones are the base for many ubiquitous computing projects.
Wireless is a term used to describe telecommunications in which electromagnetic waves (rather than some form of wire) carry the signal over part or all of the communication path. Wireless technology is rapidly evolving, and is playing an increasing role in the lives of people throughout the world. In addition, ever-larger numbers of people are relying on the technology directly or indirectly. A wireless LAN is one in which a mobile user can connect to a local area network (LAN) through a wireless (radio) connection. The IEEE 802.11 standard specifies the technologies for wireless LANs. There are several devices suitable for ubiquitous computing and that allow wireless communication between them, by means of telephone systems or wireless networks. We can point out the most common, which are:

4.1.2 Cellular phones

These devices provide connectivity for portable and mobile applications, both personal and business. Cellular telephone is a type of short-wave analog or digital telecommunication in which a subscriber has a wireless connection from a mobile telephone to a relatively nearby transmitter. The transmitter's span of coverage is called a cell. Generally, cellular telephone service is available in urban areas and along major highways. As the cellular telephone user moves from one cell or area of coverage to another, the telephone is effectively passed on to the local cell transmitter. There are several technologies currently in use: GSM (Global System for Mobile Communication), GPRS (General Packet Radio Service), UMTS (Universal Mobile Telecommunications System)

4.1.3 PDA (Personal Digital Assistant)

This term describes any small mobile hand-held device that provides computing and information storage and retrieval capabilities for personal or business use, often for keeping schedule calendars and address book information handy. PDAs can be combined with telephone systems and wireless networks

4.1.4 Tablet PC

It is a wireless personal computer (PC) that allows a user to take notes using natural handwriting with a stylus or digital pen on a touch screen. A tablet PC is similar in size and thickness to a yellow paper notepad and is intended to function as the user's primary personal computer as well as a note-taking device. Tablet PCs generally have two formats, a convertible model with an integrated keyboard and display that rotates 180 degrees and can be folded down over the keyboard -- or a slate style, with a removable keyboard. The user's handwritten notes, which can be edited and revised, can also be indexed and searched or shared via e-mail or cell phone.

4.2 Augmented reality

Augmented Reality (AR) can be defined in a very broad sense as augmenting natural feedback to an operator with simulated cues. AR systems based on head mounted displays fits well in the context of ubiquitous computing. There are two main kinds of AR head mounted displays: optical see-through and video see-through displays [6]. Optical see-through AR displays are characterized by the ability to see through the display medium directly to the world surrounding the observer. Most commonly display augmentation is achieved by using mirrors to superimpose computer generated graphics optically onto directly viewed real-world scenes. Several research and development issues have accompanied the use of optical see-through displays. These include the need for accurate and precise, low latency body and head tracking, accurate and precise calibration and viewpoint matching, adequate field of view, and the requirement for but comfortable head-mount. Some of these technological difficulties can be partially alleviated by replacing the optical see-through with a video see-through head mounted display. In this case, the computer generated graphics are superimposed to a video image and showed to the user by means of the display. That presents certain advantages but also new issues arise from the need to create a camera system whose effective viewpoint is identical to that of the observer's own eyes. AR can be a natural complement to mobile computing, as long as a mobile AR system can assist the user directly in several situations. There has been a lot of research for creating AR mobile set-ups using mobile personal computer hardware [7].

4.3 User location

Knowledge about the location of a person (and also of a device) can be useful for ubiquitous computing applications. The system has to detect the location information and present the required information to the user in the best way using the background computer system.

In order to detect the user location, there are two alternatives:

a) To put sensors and cameras in the room

b) To put all the detection and sensing hardware on the person, requiring no environmental infrastructure at all.

One possibility for the first approach is to use position sensors, devices that provide its location and/or orientation to the computer. These sensors require that an infrastructure is mounted in the room. One kind of position sensor is the electromagnetic tracker. It uses a Transmitter (it is fixed at a know location and orientation in the room) in order to generate a low-level magnetic field from three orthogonal coils within the unit. Each one these fields will generate current in another set of coils that it will be in a smaller **Receiver.** Unit (it is fixed on the user head, hand or in any other device manipulated by him). Thanks to the measures of the signal in each coil of receiver is possible to know its position and orientation relative to transmitter, that is, where the receiver is and how is oriented. Another kind of position sensor is the optical one. It uses visual information in order to track the user or the objects. It is possible by means of a video camera (it is in a fixed location) that acts as an electronic eye that it is “watching” the tracked user or object. Normally, this user or object will have placed a sensor device (light-sensing devices) that will be watched. Using complex computer vision techniques based on what the camera sees, it will be possible to calculate the user or object position. If the user or object have a single sensor device, their position will can be reported in only two dimensions but without depth information. Nevertheless, this problem can be solved if the user or object have multiple sensors. In this way, the system can triangulate the location and/or orientation of the tracked entity, providing three-dimensional position information. Moreover, if the system use three visual input devices (three video cameras) in different locations, it will be possible to calculate a full 6 DOF (Degrees of Freedom –a particular way in which a entity may move in space) position. One possibility for the second approach is to provide the user with a GPS receiver. The GPS (Global Positioning System) is a "constellation" of 24 well-spaced satellites that orbit the Earth and make it possible for people with ground receivers to pinpoint their geographic location. The location accuracy is anywhere from 100 to 10 meters for most equipment. Accuracy can be pinpointed to within one meter with special military-approved equipment. GPS equipment is widely used in science and has now become sufficiently low cost so that almost anyone can own a GPS receiver.

4.4 Status tracking

As we have explained, the system has knowledge at each moment of the current status of the different devices and users of the system. It is not only the location information which is important For example, the system has to know the social situation the user is, his / her emotions, his / her identity, the temperature and humidity levels of the environment, when a product was made and by whom it was made… Different sensors can be distributed in the environment or placed in the user to detect the different states of the user. Once the information has been processed, applications should benefit from the knowledge acquired and modify the current state of the system accordingly. One possible application of this user status tracking can be to develop preventive systems that help old people to stay healthy as long as possible [8]. The user can wear biometric sensors on the body (for example, cardiac monitors) that can detect a crisis if it occurs. Besides, the system can detect declines in health, using ubiquitous sensing technology at homes to detect domestic activities and changes in them. Taking this information into account, the system can also present information dynamically that can help the user to change his/her behavior in a way that is beneficial for him/her. In order to track the status of the system, one possibility is to implant a microchip loaded with information into clothing, and then use a small terminal to read and send the number sorted in the microchip to a server computer to obtain detailed information about that object [9]. One of the purposes of the system can be to track the user’s emotional state and to react accordingly. One of the ways to detect modifications in the emotional state can be recording physiological signals, for example, heart rate, galvanic skin response, temperature, electromyography, etc. Biosensors can be attached to the user’s body and this data can be analyzed while he/she is inside the ubiquitous computing system or room. Some research to develop affective wearable, sensors that are integrated in usual pieces such as pendants, earrings, gloves… has been made by Rosalind Picard [10, 11].

4.5 User interaction

Different devices can be used to achieve that the system can determine the activities and intent of the room’s participants and react accordingly. Ubiquitous computing gives a lot of possibilities to input and output information, that combined in a correct way can lead interesting and new applications. Speech recognition is one of the possibilities. Speech recognition involves the ability to match a voice pattern against a provided or acquired vocabulary. Usually, a limited vocabulary is provided with a product and the user can record additional words. More sophisticated software has the ability to accept natural speech (meaning speech as we usually speak it rather than carefully-spoken speech).

4.6 Intelligent User Interfaces

Intelligent human computer interaction1 promises to support more sophisticated and natural input and output, to enable users to perform potentially complex tasks more quickly, with greater accuracy, and to improve user satisfaction. Intelligent interfaces are becoming increasingly important as users face increasing system complexity and information overload, as expert staff levels decrease, and with corporation's increasing requirements for systems that are adaptive to global commerce and heterogeneous user populations. These systems are typically characterized by one or more of the following properties [12].

1. Multimodal input – they process potentially ambiguous, impartial, or imprecise combinations of mixed input such as written text, spoken language, gestures (e.g., mouse, pen, data glove) and gaze.

2. Multimodal output – they design coordinated presentations of, e.g., text, speech, graphics, and gestures, which may be presented via conventional displays or animated, life-like agents.

3. Interaction management – mixed initiative interactions that are context-dependent based on system models of the discourse, user, and task. This new class of interfaces promises knowledge or agent-based dialogue, in which the interface gracefully handles errors and interruptions, and dynamically adapts to the current context and situation. The overarching aim of intelligent interfaces is to both increase the interaction bandwidth between human and machine (e.g., by increasing interactive media and modalities) and at the same time increase interaction effectiveness by improving the quality of interaction. For example, by explicitly monitoring user attention, intention, and task progress, an interface can explain why an action failed, predict a user's next action, and warn a user of undesirable consequences of actions, or suggest possible alternative actions.

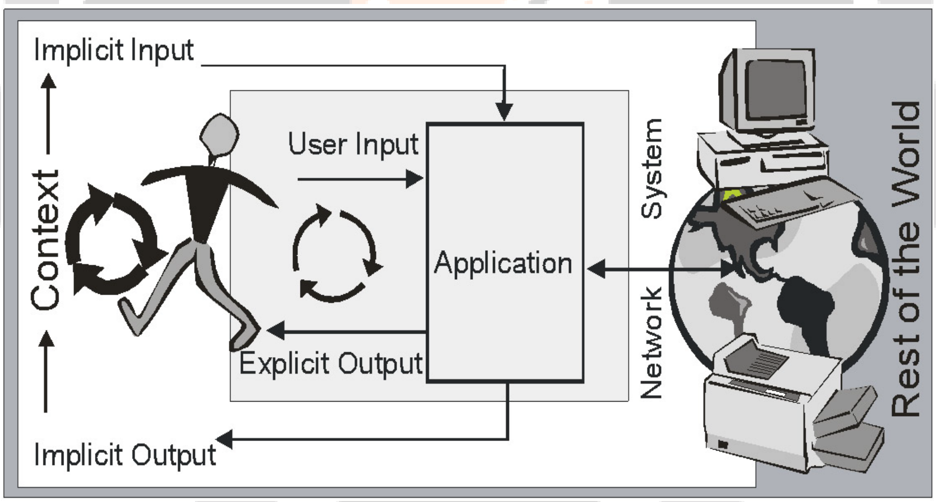

Fig -2 Implicit human computer interaction model

4.7 State of the art of IUI

As Section 5 details, intelligent human computer interaction includes analysis of input, generation of output, management of interaction, modeling and adaptation to the user, and support for interaction with the underlying system. The table outlines the evolution of synergistic multimodal input, coordinated multimodal output, tailored dialog control, and detailed tracking and reacting to models of the user and discourse. In addition to supporting a much richer range of interaction styles, interface advances enable the user to do things they perhaps could not otherwise. Several areas a worth highlighting as key interface trends to watch. These include the growth of agent communication languages, the introduction of affect into the interface, and the growing focus on awareness and knowledge management, each of which we briefly describe.

4.7.1 Intelligent Interface Agents Advances in tools and techniques for control of knowledge rich components is being advanced by specific architectures such as the Open Agent Architecture (OAA, http://www.ai.sri.com/~oaa) but also by government initiatives such as the Distributed Agent Markup Language (www.daml.org) and the semantic web (www.w3.org/2001/sw, www.semanticweb.org)

4.7.2 Affective interfaces Recognizing and expressing mood and emotion via the interface has received increased interest. This could come, for example, in the form of detecting delight or stress via language, speech, and gesture or expressing emotional displays via an interactive life-like agents. It could also be as practical as detecting and effecting drowsiness in a car driver interface

4.7.3 Awareness The explosion of Instant Messaging (IM) and associated presence information has increased user desire for /information regarding user identity, physical and virtual location, activity (e.g., idle, working), availability, and communication capability (e.g., platform, interactive devices, network connectivity). In addition to Awareness of individual characteristics, there also is a need for awareness of the emergence and tracking of group activity and roles participants play (e.g., who is the leader, facilitator, key contributor)

4.7.4 Knowledge Management. Strongly related to awareness are areas necessary to support knowledge access, including:
- **Expert Discovery:** Modeling, cataloguing and tracking of distributed organizations and communities of experts.
- **Knowledge Discovery:** Identification and classification of knowledge from unstructured multimedia data.
- **Knowledge Sharing:** Awareness of and access to enterprise expertise and know-how.

4.7.5 Intelligent Interface Agents

Intelligent (User) Interface Agents are fairly recent developments that use an agent oriented approach to the construction of such systems. The major factors that distinguish Interface Agents from any other IUI is the fact that agents are proactive and enjoy a degree of autonomy. These properties could manifest themselves in a number of different ways, for instance one set of agents discussed below undertakes an information filtering role based upon perceived user interests. This role may involve actively seeking information with the filtering is undertaken with limited or no intervention on the part of user. In addition to these general properties it is usual for an interface agent to fulfill at least some of the following roles :

• Assisting the user in communicating their task to the rest of the system. This typically involves presenting the user with an easy to use interface which hides from them the actual underlying system which may be very complex. This should also provide benefits to system developers, allowing them to easily increase the functionality of the existing system by simply slotting in another functional component

• Learning the user profile. The system interacts with the user via the interface that the interface agent provides. Thus this is the logical component of the system to attempt to build up a profile of the user. This should be based upon the user's behavior in terms of interactions with the interface and the agent's knowledge of the semantics attached to the individual interface components

• Selecting for presentation components of the system's functionality. This should be consistent with the user profile if available and users current interaction with the user interface. The agent is also responsible for presenting them to the user in a timely appropriate and accessible manner. Another somewhat controversial aspect of agent based IUIs is the whole issue of personification. The persona of an agent is the visible presence of the agent from the users perspective. At one extreme several people are working on highly agents which attempt to convey the whole range of human emotions [13]. At the other extreme a number of Human Computer Interaction (HCI) workers lead most prominently by Schneiderman [14] are somewhat opposed to agent based interface solutions and particularly to the personified type, claiming they remove user control and are distracting. Of course a large number of people fall between these two extremes, one prominent exponent of the agent based approach who doesn't try to highly anthropomorphise agents is Maes [15]. Of course there exists a myriad of different possible technologies and architectures which could be used to implement any kind of agent based interface system.

4.7.6 Affective computing

Affective Computing is defined as "computing that relates to, arises from or deliberately influences emotions", by Picard [16], who coined the term. In the last years, work done in neuroscience and psychology has radically changed the view according to which emotions only serve to hinder reason. Although there are situations in which emotions can impair reason, more often than not emotions are essential to rational reasoning, decision making, human communication, to name a few of the things we all do in our daily lives. Since emotions play a fundamental role in human communication, and many of the existing human-computer interfaces are not always very pleasant for humans, it is only natural that an important area of application of affective computing is in human-computer interfaces. It should be said from the outset that this doesn't mean that affective interfaces should be present in all computational systems. It should also be said that affective interfaces can be used in wrong and unethical ways, if the intention is to manipulate and/or dupe users. But there certainly are many beneficial applications of affective interfaces, one of the most important of which being in the construction of tutoring systems, especially for children. The aim of tutoring systems is to guide a student through the learning of some subject. Just as what happens with human tutors, certain emotional and emphatic characteristics of the tutor are essential to effective learning. One essential factor to this is the capacity of the tutor to engage the student in the process of learning. Most important to achieve this engagement is the ability of the tutoring system to show some understanding of the student's emotional state, and have this understanding reflect on what the next interaction should be, as well on what affective state should be displayed by the computer to accompany this interaction. Although it is possible for a computer to elicit an affective state in a user, by doing nothing having to do with emotions, or by simply showing the user a smile or a frown, this is not what affective interfaces are about. Affective interfaces involve several different aspects like the recognition of the user's affective state, the generation of the computer's affective state, and the expression of this state by the computer. Just as happens with humans, a computer should have the user's affective state into account when interacting with the user. The recognition of the user's affective state can be done through such means as the measurement of physiological signals, the analysis of facial expressions, voice tone, gestures, the strength of keystrokes, etc., as well as by inferring what the user's affective state should normally be, from the knowledge of the user's goals, past behaviors, etc. and an evaluation of the situation, using an appraisal emotion theory. Obviously, some of these tasks involve as much specialized hardware as software. The same emotion theory may be used to generate the computer's affective state, based on the user's affective state, and on the computer's goals, among other factors.

Finally, the computer's affective state should be made apparent to the user, which is normally done through facial and/or bodily expressions. According to hook [17], the evaluation of affective interfaces should take into account the following aspects:

- How well are emotions expressed by the system understood by users?
- Are the users' emotions correctly interpreted by the system?
- Finally, does the system achieve its main goal of helping or entertaining the user?

5. Interface Challenges and Benefits

Interface function	State of the art	Challenges	Benefits
Input Analysis	Sequential keyboard and two dimensional mouse or touch screen input. Limited spoken language input.	Interpretation of imprecise, ambiguous, and/or partial multimodal input	Flexibility and choice in alternative media input, synergistic input, robust interpretation.
Output Generation	Canned presentations utilizing primarily graphics and text. Single document, mono-lingual summarization.	Automated generation of coordinated speech, natural language, gesture, animation, non-speech audio, generation, possibly delivered via interactive, animated life-like agents.	Mixed media (e.g., text, graphics, video, speech an non-speech audio) and mode (e.g., linguistic, visual, auditory) displays tailored to the user and context. Life like animated characters.
Dialog Control	Pre-scripted interactions with standard dialogue presentations (e.g., windows, menus, buttons)	Mixed initiative natural interaction that deals robustly with context shift, interruptions, feedback, and shift of locus of control.	Ability to tailor flow and control of interactions and facilitate interactions including error detection and correction tailored to individual physical, perceptual and cognitive differences.
Agent/User Modeling	Limited models of user interests (e.g., via explicitly solicited user models). Recommender technology.	Unobtrusive learning, representation, and use of models of user/agents, including models of perception, cognition, and emotion.	Enables tracking of user characteristics, skills and goals in order to adapt and enhance interaction.
API	Variable specification of underlying application functionality. Move toward component based architectures.	Addressing increasingly broad, interdependent, and complex application functionality.	Simplification of functionality, possibly limited by user and/or context models. Automated task completion. Task help tailored to situation, context, and user.

6. CONCLUSIONS

In Ubiquitous Computing and ambient intelligence most systems consider that there are humans in the loop. These systems are obviously interactive. As humans interact in many ways with their environment the term interactive application goes beyond the well established user interfaces. Traditional user interaction is in most cases dialog oriented whereas the communication and interaction between humans and humans and also between humans and their environment is much richer. In particular the situation in which a communication takes place has a significant role for the common understanding. Taking the environment into account a new interaction model can be established regarding explicit as well as implicit interaction. This model can be used to explain different application areas of context aware systems. Implementing systems that make use of context information require basic design decisions on the way context is integrated. Basically pushing context to the system and eventually to the UI and pulling context from the resource are the two pure options. Integrating computing technology into everyday objects also addresses the issue of physical disappearance. But building invisible systems the designer is always subject to the dilemma between true invisibility and added value. Including technology that provides added value of a certain form will in many cases trigger the ingenuity of the user and make her use the object differently. Object and artefacts which could be used for their original purpose transparently become different objects because they are a manipulator for the digital world.

AmI research must focus on developing user-friendly low-cost solutions with a high level of network security. This involves seamless integration of nano- and opto-electronics, natural user interfaces and integration of electronics in new computing substrates like fabrics and plastic. The tools used for designing AmI applications, the software running on them and the communications infrastructures are technological challenges to be solved within the next few years.

7. REFERENCES

[1] Xerox PARC online: http://www.parc.xerox.com.

[2] M. Weiser, Some computer science issues in ubiquitous computing. *Communications of the ACM* 36**7**, (July 1993) 75-84.

[3] Buxton, W. (1995). Ubiquitous Media and the Active Office. Published in Japanese (only) as, Buxton, W. Ubiquitous Video, *Nikkei Electronics*, 3.27 (no. 632) (1995),187-195.

[4] Ubiquitous computing online: http://www.cc.gatech.edu/classes/cs6751_97_fall/projects/gacha/daniels_essay.html.

[5] S.S. Intille, V. Lee, and C. Pinhanez. (2003) Ubiquitous Computing in the Living Room: Concept Sketches and an Implementation of a Persistent User Interface, *Proceedings of UBICOMP 2003 Video Program*.

[6] P. Milgram, H. Takemura, A. Utsumi,, F. Kishino, Augmented reality: a class of displays on the realityvirtuality continuum. in *SPIE Vol. 2351* (1994)*: Telemanipulator and Telepresence Technologies.*

[7] D. Wagner, D. Schmalstieg, First Steps Towards Handheld Augmented Reality. ISCW 2003.

[8] Intille, S.S. (2003). Ubiquitous Computing Technology for Just-In-Time Motivation of Behavior Change, *UbiHealth Workshop 2003*.

[9] K. Sakamura,, Ubiquitous Computing: Making It a Reality. ITU Telecom World 2003.

[10] R. Piccard, J. Healey, Affective wearables (1997), *Personal Technologies* **1** (1997), 231-240

[11] J. Scheirer, R. Fernández, R. Picard Expression Glasses: A Wearable Device for Facial Expression Recognition, *Conference on Human Factors in Computing Systems* (1999).

[12] M. Maybury and W. Wahlster, (eds.) *Readings in Intelligent User Interfaces*, Morgan Kaufmann Press, 1998 .

[13] J. Bates, *The Nature of Characters in Interactive worlds and The Oz Project. Virtual Realities: Anthology of industry and Culture*, Ed. C E Loeffler, 1993.

[14] B. Scheiderman, Direct Manipulation for Comprehensible, Predictable and Controllable User Interfaces. In *Proceedings of Intelligent User Interfaces* (1997), Orlando Florida.

[15] P. Maes, Intelligent Software. In *Proceedings of Intelligent User Interfaces* 1997, Orlando Florida.

[16] R. Picard, *Affective Computing*, Cambridge, MA: The MIT Press, 1997.

[17] K. Höök, Evaluation of A_ective Interfaces, *Workshop on Embodied Conversational Agents*, in conjunction with *The First International Joint Conference on Autonomous Agents and Multi-Agent systems*. www.vhml.org/worshops/AAMAS, Bologna, Italy, 2002.