Ambient Intelligence

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1 A Concept Takes Shape

The concept ambient intelligence was first introduced more than ten years ago by the EU Information Society Technologies Advisory Group (ISTAG 1999). The result was a visionary description of a technological development in which information and communication systems are embedded in the user environment and enable numerous ways of individual support from the background. Until now, the term has played a secondary role in the German-speaking research community of business and information systems engineering (BISE). Instead, synonymous terms like pervasive computing or ubiquitous computing have been used (cf. e.g. Mattern 2001). The journal *it – Information Technology* was the first to dedicate an exclusive issue to the topic in a special issue (n.a. 2008). Moreover, some papers in the context of sub conferences as part of the Multi-Conference on Information Systems (MKWI) dealt with and identified ambient intelligence. Furthermore, the use of the concept, which has become known as "Ambient Assisted Living (AAL)", is presently on the increase. One possible explanation for the more frequent use is the link with various AAL-related initiatives and their respective funding programs at both the federal and the EU level.

The use of the term ambient intelligence is much more widespread when seen in an international context, especially in Europe. To illustrate this phenomenon, the *Journal of Ambient Intelligence and Smart Environments* (n.a. 2009), an independent journal dedicated to this subject, began publishing in 2009.

The objective of this catchword is to introduce the originally European conception Ambient Intelligence as part of its more than 10th anniversary celebration and to delimit it from related concepts. Moreover, the particular significance of the subject area of ambient intelligence pertaining to the German-speaking BISE research community and relevant fields of activity is illustrated by two examples.

2 Ambient Intelligence Characteristics

Literature shows that ambient intelligence has often shown common characteristics to related concepts such as: ubiquitous computing, pervasive computing, and (situational) mobile computing. Notwithstanding, ubiquitous computing – for example – is often understood more as an academic concept and idealistic in nature, whereas pervasive computing is perceived as a concept pertaining to the industrial sector (Mattern 2001). Hence, significant differences exist with regard to the origin of the various concepts and their objectives. **Table 1**, with the use of short examples, separates and distinguishes these concepts from one another.

A central unique characteristic of ambient intelligence, in comparison to the other mentioned concepts, is the use of artificial analytic intelligence, which allows the (independent) initiation of actions within the system. Both ubiquitous computing and ambient intelligence are characterized by a high degree of integration within the environment. However, ubiquitous computing focuses more on specific technical implementation. In contrast, ambient intelligence is more visionary; people and their needs are represented as a central focal point.

ISTAG, which introduced the concept of ambient intelligence in 1999, describes this concept as a further development of ubiquitous computing extended by ubiquitous communication as well as intelligent user-friendly interfaces (ISTAG 1999). In an ambient intelligence environment people are surrounded by various interfaces, computer and network technologies being embedded in the objects found in daily life. Examples of such objects include furniture, clothing, automobiles, roads, or even so-called smart materials which work together seamlessly in their respective environment. Such an environment takes into account the specific habits and needs of people and is capable, intelligent, and adaptive to respond to spoken language or gestures. The corresponding systems support the user along largely unobtrusive sidelines.

To avoid restricting the concept of ambient intelligence from the beginning, ISTAG (2003) rejected a narrow definition of the term and merely describes characteristics (**Table 2**). As a result, corresponding publications have provided definitions of ambient intelligence that have been shown to differ substantially. For example, Fabian and Hansen (2006) theorize that ambient intelligence implies the assumption that all the problems concerned with acceptance have already been resolved, in order to better emphasize its visionary character. However, this assumption is hardly mentioned in remaining literature. Shadbolt (2003) complements the approach of the ISTAG to mobility issues. Mobile users can subsequently move within the ambient environment and use mobile technology to communicate with the appropriate system. Moreover, the position of the user and various objects in the appropriate environment will be delineated, enabling

Table 1 Distinction of the concept ambient intelligence

Term	Origin	Focal point	Example
Ambient intelligence	ISTAG (1999)	Devices are linked by a network that flexibly collects and analyzes data as well as derives actions autonomously.	An ambient system monitors and analyses the behavior of an apartment's occupant and regulates the heating system accordingly.
Ubiquitous computing	Weiser (1991)	A large number of invisible computers are linked and the related virtual and real worlds are merged.	In a library, sensors in the books allow the loaning process to take place both independently and unobtrusively.
Pervasive computing	Ark and Selker (1999); Hansmann et al. (2001)	Permanent access to information is provided through remote computers; and the ability to respond accordingly is made possible.	Frozen products are temperature controlled by sensors during the entire delivery process in order to maintain their desired temperature as required.
Context-dependent mobile computer applications	Müller-Veerse (1999)	While taking contextual user requirements into account, mobile technological applications facilitate respective activities, processes, and applications.	A device's location is ascertained through the use of a GPS-enabled mobile phone; and relevant objects in the vicinity (points of interest) are subsequently displayed to the user.

Table 2 Characteristics of ambient systems as defined by ISTAG (1999, 2003)

Characteristics	Comments
User friendly	A simple and intuitive operation that also reacts to gestures and language.
Intelligent	High analytical skills, which enable a target-orientated and flexible support system.
Embedded	The system is configured by the use of a variety of components that are integrated within the user environment.
Personalized	The user can customize the system to meet his/her personal requirements.
Adaptive	System components may vary depending on individual requirements.
Unobtrusive	Although the system components are not directly visible, they provide support from the surrounding environment.

possible contextual features. Weber et al. (2005) also expand the characteristics of ambient intelligence to include a high degree of trust in the use of information, explicitly addressing the importance of security issues as regards privacy.

In view of the large number of various definitions, it does not seem to be sensible to refer to ambient intelligence systems only when all of the above characteristics are met. Graded definitions in the sense of the degree of ambient characteristics should be favored. The process as described in the example of environmental monitoring in **Table 1** consequently points out ambient features that are unequivocally unique. Two application scenarios shall be presented in order to further develop the characteristics of ambient systems.

3 Application Scenarios

The following scenarios stress the supportive nature of ambient intelligence which is reflected in its enabling humans to use the involved equipment in an as far as possible natural way, taking into account individual and context specific factors. However, it is important to mention that, although both scenarios display several ambient characteristics, the ambient nature could be enhanced by additional applications built on the same infrastructure. Hence, the scenarios are intended as examples in order to provide an overview of the possible tasks that ambient intelligence can undertake.

3.1 Collaboration in Learning and Knowledge Processes

In addition to more traditional applications, such as in sales and distribution, production, material management, etc., ambient technologies can also promote collaborative knowledge and learning processes (Bick et al. 2007): For example, a physician in a hospital may be involved in the diagnosis process which the physician, acting alone, cannot adequately resolve. When the physician is amidst an ambient environment, he or she is able to work at the hospital by using a respective (mobile) device displaying a hospital floor plan which would in turn show the location and indicate the status of some specialists. Through the use of an integrated search function, the physician can quickly identify an available specialist who can assist in a resolution of the problem. Another physician, who is currently engaged with surgery, may be invited to contribute consultation at a later time. This allows a spontaneously formed team to discuss shared information. Data pertaining to the relevant patient is made available for the physicians on their individual devices. Unfortunately, if neither of the two physicians can play a role in solving the problem, they may have to wait for their colleague arriving late from surgery who then might remember a similar, previous case. Since he cannot recall the whole case, the third physician searches the hospital repositories using the biometric data of the patient to identify related cases his colleague has dealt with. Based on the results, the physicians can now decide on further examinations and treatments. In constructing such a plan, the ambient system automatically offers additional investigative steps that can be adapted by the physician in charge. The examination results are available a few days later. The disease has been diagnosed, and all participants receive a report that summarizes the final results. Furthermore, the diagnosis and the progression of the disease

are documented in a standardized manner so that the respective data can be easily used context-specifically in future similar cases.

By using the ambient system, participants were able to link their knowledge and expand the corresponding data in the process. The result is an increase in direct personal networking between participants. Hence, inter-departmental cooperation can be supported which is particularly well suited for large hospitals.

3.2 Ambient Assisted Living

Additional applications of ambient technologies can include the possibility to help ease a patient's hospital stay and to facilitate the transition to home care after the patient's release. In implementing the specified characteristics, Ambient Assisted Living (AAL) aims to assist people from all walks of life who are in need of help to remain independent and to conduct their lives on their own. In this context, several scenarios are proposed (cf. e.g.: n.a. 2010). In terms of an ambient environment, a far-reaching integration of different application areas is desirable. The aim is to use patient information in a hospital not only for the purpose of localization, but also for instance to coordinate examinations and to aid the patient moving through the hospital. Such an application could be connected to a support system for the lighting that automatically switches on when patients leave their beds.

Another possible application of ambient technologies includes adequate support for the dispensing and administration of drugs during the transition to home care. Such environments can also be used for prevention purposes. Furthermore, ambient technologies could also be applied in the field of telemedicine as a method to automatically collect biometric data continuously in the home environment, to communicate when fluctuations occur, and to pass the information on to the physician in charge. As a result, approved health care methods can be ensured over great distances. In addition to these possible applications, family members or others involved with the care process can also access all information that is required to support the patient.

4 Significance for the German-speaking BISE

Various different business information system tasks have become evident alongside the two scenarios. In addition to prototypes that already exist, more comprehensively integrated ambient systems should be scientifically supported, from their development through the implementation stages. The focus here is on architectures, platforms, tools, and the development of standards. In addition to this, an especially high degree of importance is attached to the identification of adequate application areas. The intelligent refrigerator might seem useful as an illustration of a possible technical application. However, its commercial viability remains doubtful. We can observe a gap between the expectations of developers and the real needs of users, especially in this area. In this context, the German-speaking BISE research community is required to identify and evaluate potential benefits and appropriate business models. Problems and issues as they relate to feasibility and efficiency are particularly relevant for provider orientation. However, this research's objective is simultaneously the development of existing prototypes into marketable applications. This is specially true due to the lack of adequate business models that reduce the significant initial investments for both providers and demanders alike.

Extremely powerful sensors and mobile systems are already available today. Research related to coordination systems plays an additional critical role in ambient intelligence, as the coordination system takes on the task of managing various devices in the system, including the services offered. As a result, the development of an interface design and the establishment of standards by means of dynamic integration of a variety of different devices gains considerable importance.

Additionally, this system must possess analytical intelligence in order to be able to evaluate the large amount of data collected and then to process it for the appropriate tasks. The system must, therefore, be able to learn and adapt to the user's habitual actions. Consequently, it is necessary to examine how the required personalization of the system can be technically implemented. Here, the addition of mobile devices that can incorporate gesture and speech recognition capabilities are being considered. It is highly important to explore which of the alternatives are particularly promising in terms of functionality and ease of use. From the user perspective, the question will certainly arise as to how independent the ambient system should be.

Due to the wide variety of devices that are involved in the collection, storage, and analysis of data, there is a substantial increase of both quantity and quality of personal information. This can result in completely new kinds of data abuse, including the surveillance of individuals. This has far reaching concerns for the individual and the professional environment alike. It is, therefore, imperative that sensitive data be protected from unauthorized access. This aspect has particular relevance as in the long run ambient intelligence can only be implemented if there is a sufficient degree of confidence on the part of users that overcome presently prevailing fears.

5 Conclusion

The concept of ambient intelligence is not fundamentally new. Notwithstanding, it is gaining importance due to its increased presence in the field of Ambient Assisted Living. This paper highlights numerous research opportunities that exist in the field of BISE. Here, the central question is how ambient systems can specifically support individuals contextually in a given environment (work, leisure, etc.) and how this can be technically achieved.

The German-speaking BISE research community as well as practitioners should become actively involved so as to answer this question. This is especially desirable because ambient intelligence is a concept which has its origins in Europe. Moreover, the transition from a visionary approach to suitable real-life applications will in fact take place in the coming years.

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