Remarks on Ubiquitous Intelligent Supportive Spaces

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Abstract: - Ubiquitous computing applications and technologies, frequently studied also under the name ambient intelligence, are more and more matured to be able of creating an environment that is intelligently helpful to users surrounded by such an environment. Besides other helpful application we may consider them also as being very suitable for intelligent workplaces development. In the paper some discussion about basic features of such intelligent workplaces for managers is presented, and a couple of remarks related to possible problems that could arise in such ubiquitous intelligent spaces are presented as well.

Key-Words: - Human-Machine Systems; Knowledge Technologies; Ubiquitous Computing Applications

1 Introduction

The recent Knowledge-based Society should be enabled also by existence of such environments which are rich of knowledge and thus in a well defined sense supportive to people surrounded by the environment. Such environments (often called also smart spaces or intelligent environments) have been particularly studied in the scope of the area of Ambient Intelligence, mainly from the enabling technologies point of view.

Ambient intelligence approaches and technologies are more and more matured to be able of creating an environment that is intelligently helpful to users surrounded by such an environment. Besides a number of well known applications of this concept in various areas, like smart home environment, or smart support to elderly or handicapped people [3], we may consider it also as being very suitable for intelligent workplaces development.

An intelligent workplace can be, among its other features, also helpful in managing knowledge which can be usefully needed by the users working in the workplace. Such knowledge can be used not only for solving various problems requiring some expert knowledge to be properly solved, but also for learning at the workplace when creating decisions or looking for solutions of difficult tasks.

In our paper, based on recent research ([5] to [8] and [15] to [19]) we wish to stress the role of knowledge and of its management in such intelligent environments of various kinds. Such environments inevitably need to be rich of knowledge; therefore a synergy of approaches and techniques from ambient intelligence as well as from knowledge management is necessary. We present an analysis of what are the basic common features of intelligent (and therefore knowledge rich) environments, what are they relations to ambient intelligence approaches, and what other serious problems could arise.

In our paper besides some more general discussions we wish to specify basic features of such an intelligent workplace, which can be helpful in overcoming some barriers and stressful situations typical for managerial decision making. The workplace should, among its other features:

- ensure broad but focused (and personalized) access to relevant information and knowledge resources, supporting thus both learning needs of the manager as well as creation of his/her decisions;
- offer as much relief from stress as possible by avoiding all the usual stressful situations (or more precisely their potential sources);
- ensure broad and up to date technical support for all technically based activities in the workplace.

2 Smart Supportive Workplaces

Managers, in order to be able of producing the best possible strategic decisions, should have the right information in the right time. However, without having the appropriate knowledge the production of good decisions would not be easy, if not impossible. It is, therefore, quite sensible to think about such a managerial workplace, where the manager would have the best possible working conditions in various meanings of this formulation.

What are the most natural aspects of managerial work? First of all, a manager has to have an access to all the

necessary information on which the best decision can be built. In order to ensure it, it is necessary to be aware of having as good information as it is possible, and moreover, this information must be supported by knowledge relevant to the application or exploitation of particular information. According to [21] management is a process by which organizational goals are achieved through the use of various resources. All managerial activities revolve around and are carried out through continuous decision making, and are very much knowledge based, or knowledge rich. The managerial decision making or support involves the following steps:

- Identifying and defining the problem (a decision situation: an opportunity or trouble).
- Classifying the problem into a standard category.
- Constructing an abstract model that describes the real-world problem.
- Finding potential alternative solutions to the modelled problem and evaluating them.
- Selecting and recommending a good enough and appropriate solution to the problem.

The nowadays decision making environment is changing very rapidly, because business and its environment are more complex today in the global market. The decision making function has become more complex for several reasons. First, the number of available alternatives is much larger today than ever before because of the improved technology and communications systems, especially the availability of the Internet and its search engines. Second, the cost of making errors can be very high because of the complexity and magnitude of operations, automation, and the chain reaction that an error can cause in many parts of the organization. Third, there are continuous changes in the fluctuating environment and more uncertainty in several impacting elements. Finally, decisions must be made quickly. Factors causing complexity of managerial decision making are mainly as follows [21]:

- More alternatives of managerial decisions because of growth and advancement in ICT, as well as advancement and diversity in technology in general.
- Larger error cost because of increased competition, as well as increased structural complexity.
- More uncertainty because of increased consumerism, as well as decreased and fluctuating political stability.
- It is a need for quick responses because of decreased and fluctuating political stability, as well as growing, complicating and fluctuating market economy.

As a result of such complexity, managers must either become more sophisticated or must have the tools to overcome increased complexity. In our opinion, the later case is the promising direction that should be expected from the ambient intelligence (AmI) approach as a collection of sophisticated intelligent tools for managerial decision support.

The concept of a smart space is in many aspects very close to the idea of ambient intelligence, as introduced by the [13]. The smart space concept has been introduced mainly as a common basis for an intelligent environment primarily designed for on line learning. It has been studied and developed by various research groups in several different directions.

The central design element of a smart learning space is usually a dynamic learner profile, which includes learning history, learner specific information and learning goals. However, this is just a small (yet important) part of a really usable learning environment based on ambient intelligence principles. We do believe that the AmI principles can be considered as being very suitable for creating smart spaces for learning in organizations, as a part of more general intelligent environment for managerial support. Usage of the AmI principles is in this case concentrated not only on solving managers' profiling problem, but it is more complex, with a number of equally important issues (e.g. customization, context-based services, privacy issues, applications of AmI algorithms, intelligent interfaces, smart learning objects, etc.).

In one of our previous papers [19] we have explored the possibility of introducing and evaluating different ambient intelligence sub-solutions and scenarios and experimenting with them inside particular web-based applications, so-called Learning Management Systems (LMS) that were developed to enable the way of education supported by advanced information and communication technologies, known as e-learning. This approach is in our recent research developed into a more general one, leading towards a more powerful environment capable not only to support and fulfil educational needs of managers (taking into account the original idea of smart spaces for learning), but also to support their work more generally and intelligently.

Roughly speaking, a smart space is a region of the real world that is extensively equipped with sensors, actuators and computing components. In effect the smart space becomes a part of a larger information system: all actions within the space potentially affect the underlying computer applications, which may themselves affect the space through the actuators. Smart space technologies are evolving very rapidly, driven by factors including improvements in Internet access to the home, the increasing importance of teleworking and other Internet mediated business and entertainment activities, as well as the increasingly aging population.

An interesting technical solution represents e.g. the SmartOffice developed by INRIA [11]. However our approach presented further on is more conceptual than technical, postponing thus technical aspects to a later

research effort. We share the belief that a computer should not require a new way of working; it should simply augment current working modes. So, computers should be invisible, not demanding user adaptation, while at the same time offering the benefits of data-processing power. For instance, in the SmartOffice, the user can work as in a normal (even computer-free) office. Intelligent environments are designed to facilitate computer use by making computers aware of humans and enabling voice and gesture commands.

Another and a bit older direction towards smart spaces concept with a bit different meaning was described firstly by Abowd and others at the GATECH (see [1] or [10]). They proposed the development of a unique experimental facility for the exploration of large-scale ubiquitous computing interfaces and applications that are aware of the context of their use and can capture salient memories of collaborative experiences. The proposed system provided several types of assistance for users: access to information, communication and collaboration support, capturing everyday experiences, environmental awareness, automatic receptionist and tour guide.

The research by Abowd and other research directions use the name smart space mainly in the meaning of an "intelligent environment". Usually the intention behind is to design and deploy an intelligent environment capable to communicate with the user surrounded by the environment, and to support him/her in fulfilling of some rather complicated activities.

3 Some Recent Results

In a recent research project AmIMaDeS (Ambient Intelligence for Managerial Decision Support) we tried to analyze the nature of managerial work and reflecting the results of the analysis to improve managers' workplace environment by designing and implementing at least some features of the ambient intelligence approach into the environment. Our goal has been oriented on creating such an intelligent environment – based on the rather general smart space concept - that is capable to support managerial decision making as well as to fulfill managers' educational needs, simultaneously trying to educate them by an unobtrusive and natural manner, in relation to the area where the core decisions are made. One of the practical goals of the project is to create a collection of sophisticated intelligent tools for managerial decision support (IMDSS – an intelligent managerial decision support space) based on the ambient intelligence (AmI) approach.

These intelligent features are mainly oriented on an enhancement of the human contact with an IMDSS that consist of numerous variable activities and can be understood from the perspective of optional application of different AmI sub-solutions. Here we present some of the main areas of meaningful utilization of AmI principles and technologies in the developed architecture:

- user identification and logging,
- context-based services, customization, personalization and omnipresent monitoring,
- application of new programming principles and AmI algorithms,
- innovated hardware and new types of devices,
- intelligent interfaces, processing implicit inputs and interactions,
- support of communication inside the community,
- involving new types of smart learning objects,
- invisible file systems,
- affective computing,
- privacy issues,
- interaction of AmI subsystems.

Recently, the multi-agent approach based architecture is tested as the most appropriate for modelling the basic functionalities of the smart space designed. First experiences seem to be promising.

4 Some Issues and Problems in AmI

According to a popular opinion, there are three main dimensions to the problem of ambient intelligence:

- technological
- social
- political

Within the technological dimension it is necessary to study and develop technical devices, information, knowledge and communication technologies which will make the implementation of the vision of ambient intelligence possible. Key technologies might, among others, include also knowledge management, artificial intelligence, user interfaces, communication and network services, as well as solution to the problems of security and protection of data and information.

The social dimension focuses on studying the influences of social, economic and geopolitical trends on the quality of everyday life and the acceptance of using solutions employing information and communication technology (ICT) for solving problems accelerated by the above mentioned trends. Areas of problems of more global nature include for example ageing of society, multicultural society, the EU enlargement, lifelong education, the problem of consumer society, globalization, anti-globalization, etc.

The political dimension of the problem of ambient intelligence has its starting point in the resolution adopted at the Lisbon congress of the EU in 2000, on the basis of which the European Commission resolved to secure Europe's leading role in the field of generic and applied technologies for creation of knowledge society,

and thus increase Europe's ability to compete successfully, and enable all European citizens to take advantage of the merits of knowledge society. To this effect, the new technologies must not be the cause for excluding some groups of citizens from society, but must ensure universal and equal approach to its - both digital and therefore also knowledge - sources. The most controversial, breath-taking implications of the AmI vision, especially those that seem to attack the freedom of choice of humans, or to increase our dependence on the correct functioning of numerous artificial systems are logically related to its psychological dimension and represent the main barrier that can at least slow-down the acceptance of AmI approach.

The concept of AmI is strongly motivated also by economic aspects – probably economic motivation is the most significant incentive in this area. A discussion about real time or now-economy has been presented by Bohn and his colleagues [4], where more and more entities in the economic process, such as goods, factories, and vehicles, are being enhanced with comprehensive methods of monitoring and information extraction. The authors point out how two technologies, the ability to track real-world entities and the introspection capabilities of smart objects, will change both business models and consumers' behaviour.

There is also another important dimension to the problem of ambient intelligence. Let us call it the co-existential dimension. This co-existential dimension should be focused on the problem arising from the relatively simple fact that various information devices integrated into people's everyday life represented with their intelligent interfaces capable to communicate with people, can be understood as relatively independent entities with certain degree of intelligence. Their intelligence varies, of course, from rather simple level of one-purpose machines to relatively intelligent and complex systems (e.g., an intelligent building, or an intelligent vehicle). These intelligent entities co-operate one with another, and all of them from time to time have to co-operate with humans.

Considering humans also as to be another entity with various degree of intelligence, we are able to study the co-existence of various intelligent entities in real world. This will lead to an investigation of a number of different interesting aspects of such co-existence, and also to a number of potentially important consequences for human lives.

The psychological theories of different types of intelligence can help to understand human reasoning, and human interaction with machines. Each individual possesses diverse intelligences (see e.g. logical, linguistic, musical, spatial, interpersonal and other intelligences provided by [12] or analytic, creative and practical intelligences offered by [20]) in different percentages. This mixture of intelligences determines the learning style and motivations of each individual; therefore an AmI application must adopt itself dynamically to peculiarities of its users. Other psychological factor that has to be taken into account when designing AmI environments is that people tend to continue their habits, therefore the applications should respect the natural behaviour patterns of humans.

When taking into account such artificial entities with a certain degree of intelligence and with a mechanism for the initiation of its activity, where the activity is oriented on certain benefit (or service) to human beings, we are able to investigate the following basic problems related to them:

- various types or levels of such artificial entities,
- their mutual relationships as well as their relationships with humans,
- their communities (virtual as well as non-virtual),
- their co-existence, collaboration and possible common interests,
- their co-existence and collaboration with humans,
- antagonism of their and human interests,
- ethical aspects of the previous problems, etc.

All of these are interesting sources of a plethora of serious scientific questions. Some of them are discussed recently, however, a number of them remain unanswered. We hope for a further discussion in this direction.

The first impression from the AmI idea is, that humans are surrounded by an environment, in which there are microprocessors embedded in any type of objects – in furniture, kitchen machines (refrigerator, coffee maker, etc.), other machines (e.g., washing machine, etc.), clothing, toys, and so on. Of course it is depending on the type of the particular environment, there are clear differences between an environment in a hospital when compared with a luxurious private house, or in comparison with a university environment.

It is straightforward that when speaking on intelligent artificial entities able to communicate mutually, we could certainly expect some relatively intelligent behaviour of such a community. We can speak about the emergent behaviour of such a community that can be modelled e.g. as a multi-agent system, serving to some purpose considered beneficial for humans. However, the emergent behaviour of such an artificial community can be potentially dangerous – if the possible goal of the community differs from the human interests, or if the community is simply unable to serve to the human being goals from various (maybe also technical) reasons. We certainly have to take into account such questions, like:

- How to tune all the emergent behaviour of the particular environment to be able to serve the particular human being goals?

- What to do if the emergent behaviour of the environment is not in accord with the human aims, or even if it is contradictory to the intentions of the particular human?
- How the privacy of a particular human will be respected?
- Is the particular information about the concerned human safe from being exploited by another person?

Of course, these are just a few of possible questions which could arise in relation to the first attempts to introduce the AmI idea into the life. Some of other issues certainly will be mentioned in the future.

5 The Issue of Privacy

The notion of privacy and its content in an environment with ambient intelligence seems to be a very delicate as well as complicated problem. Some authors have already mentioned possible problems and risks in the area (see [4] or [18]). As a matter of fact, the main common objective against the AmI concept seems to be, that it is possibly a basis for a very sophisticated and potentially dangerous surveillance system, in a sense a kind of a new "Big Brother".

The personal privacy can be viewed from various standpoints [4]. Privacy is considered to be a fundamental requirement of any modern democracy. According to [14] it is possible to distinguish among the following motives for the protection of privacy in today's standards:

- Privacy as Empowerment – privacy mainly as informational privacy, giving people the power of controlling the publication and dissemination of information about themselves. From the AmI point of view, especially the right to control the dissemination or exploitation of the information about a particular person, collected about him/her by the intelligent environment, could be endangered seriously. New legal norms in this direction are necessary.
- Privacy as Utility – the focus is on minimizing the amount of disturbance for the individual (no unsolicited emails or phone calls). Technologically it is feasible to tailor an intelligent environment so that it is not disturbing for the human surrounded by the environment. However, there could be a complicated task of tailoring the environment to be suitable for two, three, or more persons at the same time.
- Privacy as Dignity – this is not only about being free from unsubstantiated suspicion, but also about equilibrium of information available between two people. The balance (equilibrium) of information between a person and the surrounding intelligent environment could be a serious problem because of their conflicting aims: the environment in a sense "wishes to know" everything about the human in order to serve him efficiently, while for the human it is usually not necessary to be aware what the environment is about. The problem of unsubstantiated suspicion seems to be much more serious one, as the vast information about the concerned person will be collected somewhere in the common memory of the intelligent environment, which can be considered, from the previously mentioned point of view, to be a sophisticated surveillance system. New legal norms are here more than necessary.
- Privacy as Regulating Agent – privacy laws and moral norms can also be seen as a tool for keeping checks and balances on the powers of decision-making elite. In an intelligent environment it will certainly be easy to gather information of certain type enabling to limit or prevent the society from certain type of improper behaviour. On the other hand, there should be a subtle borderline between the information necessary for the social prevention and information potentially endangering the human right for privacy.

6 Conclusions

As Bohn and his colleagues pointed out [4], the fundamental paradigm of ambient intelligence, namely the notion of disappearing computer (computers disappear from the user's consciousness and recede into the background), is sometimes seen as an attempt to have technology infiltrate everyday life unnoticed by the general public in order to circumvent any possible social resistance [2]. However, the social acceptance of ambient intelligence will depend on various issues, sometimes almost philosophical ones. The most important issue seems to be our changing relationship with our environment.

We would not be surprised by a broad social acceptance of this new, recently developed phenomenon in a short horizon of a few years. According to Dryer et al. [9] "our inevitable future is to become a machinelike collective society. How devices are used is not determined by their creators alone. Individuals influence how devices are used, and humans can be tenaciously social creatures." Actually, based on our experience, we cannot agree more, however, social consequences that ambient intelligence may have will certainly be addressed in a broad debate and a deep and focused research.

Our approach based on rather wide employment of ambient intelligence technology opens also a number of related ethical and privacy questions which must be solved simultaneously with introducing of the technology. We have to analyze the most important from

a big variety of such questions. Nevertheless, we believe that the approach chosen will lead eventually to creation of a modern and supporting working environment especially suitable for organizational learning (on workplace) and knowing (ensuring an access to all the organizational knowledge any time, when necessary). On the other hand, it promises also a number of interesting theoretical results.

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References:

[1] Abowd, G.D.: Classroom 2000: An Experiment with the Instrumentation of a Living Educational Environment. *IBM Systems Journal. Special issue on HCI / Pervasive computing*, 38 (1999) 508–530

[2] Araya, A.A. Questioning Ubiquitous Computing. *In Proc. of the 1995 ACM 23rd Ann. Conf. on Computer Science*. ACM Press, 1995.

[3] Augusto, J.C., Shapiro, D. (eds): *Advances in Ambient Intelligence.* IOS Press, 2007, ISBN 9781586038007

[4] Bohn, J. et al. Social, Economic and Ethical Implications of Ambient Intelligence and Ubiquitous Computing. *In Ambient Intelligence*, Springer-Verlag, 2005, pp. 5-29

[5] Bureš, V., Čech, P.: Ambient Intelligence and Support of its Development from an Educational Perspective, *In International Congress on Pervasive Computing and Management*, New Delhi, India. Published by Sydney College of Management, Australia, p. 26 (1-9), 2008, ISBN 978-0-9805956-0-4

[6] Bureš, V., Čech, P.: Complexity of Ambient Intelligence in Managerial Work. *In: 12th Annual Conference on Innovation and Technology in Computer Science Education.* Dundee, 2007, p. 325, ISBN 978-1-59593-611-0

[7] Bureš, V., Čech, P.: Knowledge Intensity of Organizations in Knowledge Economy. *In WEBIST 2007, Third International Conference on Web Information Systems and Technologies*. Barcelona, 2007, pp. 210-213, ISBN 978-972-8865-79-5

[8] Bureš, V., Čech, P.: Recommendation of Web Resources for Academics: Architecture and Components. *In WEBIST 2007, Third International Conference on Web Information Systems and Technologies*. Barcelona, 2007, pp. 437-440, ISBN 978-972-8865-79-5

[9] Dryer, D.C., Eisbach, C., Ark, W.S. At what cost pervasive? A social computing view of mobile computing systems. *IBM Systems Journal*, 38(4) 1999, pp. 652-676.

[10] Essa, I., Abowd, G., and Atkeson, C.: Ubiquitous Smart Spaces. *A white paper submitted to DARPA*, February 1998.

[11] Gal, C. L., Martin, J., Lux, A., Crowley, J.L.. Smart Office: An Intelligent Interactive Environment, *IEEE Intelligent Systems*, July/August, 2001

[12] Gardner, H. *Frames of mind: the theory of multiple intelligences*. New York: Basic Books Inc., 1985.

[13] ISTAG - *Scenarios for Ambient Intelligence in 2010*. Luxembourg, 2001.

[14] Lessig, L. Code and Other Laws of Cyberspace. New York: Basic Books, 1999.

[15] Mikulecký, P.: Ambient Intelligence and Smart Spaces for Managerial Work Support. In: *Proc. of the IE07 – The 3rd IET International Conference on Intelligent Environments*, The Institution of Engineering and Technology, London, 2007, 560-563

[16] Mikulecký, P., Lišková, T., Čech, P., Bureš, V. (Eds.): *Ambient Intelligence Perspectives* (Selected Papers from the First International Ambient Intelligence Forum 2008), IOS Press, Amsterdam, 2009, ISBN 978-1-58603-946-2

[17] Mikulecký, P., Olševičová, K.: Smart Spaces for Intelligent Managerial Environments. In: *Nunes, M.B., McPherson, M. (eds.): Proc. IADIS International Conference eLearning*, Lisbon, Vol. II, IADIS Press, 2007, 117 – 120

[18] Mikulecký, P., Olševičová, K., Ponce, D.: Ambient Intelligence - Monitoring and Supervision of New Type. In: *Monitoring, Supervision and Information Technology (eds. P. Kleve, R.V. De Mulder, C. van Noortwijk)*, 2nd ed., LEFIS Series 1, Prensas Universitarias de Zaragoza, 2007 , pp. 115-134, ISBN 978-84-7733-962-5

[19] Olševičová, K., Mikulecký, P.: Learning Management System as Ambient Intelligence Playground. *International Journal of Web Based Communities (IJWBC)*, Vol. 4 No. 3, 2008, pp. 348-358.

[20] Stemberg, R.J. Beyond IQ: *A Triarchic Theory of Human Intelligence.* New York: Cambridge Unviersity Press, 1985.

[21] Turban, E., Aronson, J.E., Liang, T.-P.. *Decision Support Systems and Intelligent Systems, 7th ed.*, Prentice-Hall, Upper Saddle River, NJ, 2006.