LEARNING MANAGEMENT SYSTEM AS AMBIENT INTELLIGENCE PLAYGROUND

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ABSTRACT
The vision of Ambient Intelligence (AmI) offers the conception of systems and applications that will be sensitive and responsive to the presence of humans. The AmI vision builds on advanced results of interdisciplinary research. The development of AmI environments is a complex task and all their features and functioning can neither be predefined nor forecasted because of different emergent or synergetic effects. Learning management systems (LMS), web-based educational applications, can serve as an experimental area where AmI solutions can be developed and tested. The list of possibilities starts with hardware-oriented innovations and goes over particular experiments with AmI algorithms to the evaluation of users’ reactions and responses of the proposed AmI systems.

KEYWORDS
E-learning, learning management system, ambient intelligence.

1. INTRODUCTION

The most profound revolutions are not the ones trumpeted by pundits, but those that sneak in when we are not looking.

(Mark Weiser)

The objective of the paper is to explore the possibility of introducing and evaluating different Ambient Intelligence (AmI) sub-solutions and scenarios and experimenting with them inside particular web-based applications: learning management systems (LMS) that were developed to enable the way of education supported by advanced information and communication technology, known as e-learning.

In the following paragraphs (1) we shall remind the concept of AmI and its dimensions briefly, (2) we shall argue for the suitability of LMS as an experimental area for novel AmI applications and (3) we shall offer a set of perspective research directions that promise to be beneficial both for future LMS-like applications and for AmI environment evolution.

The paper presents partial results of two consecutive research projects, where the first one has been focused on introducing more intelligence and knowledge support into a university environment, and the second one deals with AmI based solutions development focused on supporting decision processes of different types of decision makers. Related results can be found in [Mikulecky and Olsevicova], where AmI scenarios were explored in relation to university education, or in [Mikulecky2005], where some controversial impacts of AmI vision to everyday life were discussed.

2. AMBIENT INTELLIGENCE VISION

The concept of ambient intelligence (AmI) was introduced in the ISTAG report [ISTAG 2001] and interpreted e.g. by [Alcaniz and Rey; Remagnino et al; Bohn et al; Snijders] and others. This concept provides a vision of society of the future, where the people will find themselves in an environment of intelligent and intuitively usable interfaces, ergonomic space in a broad sense, encompassing better, secure
and active living environment around them, capable of aiding them with daily chores and professional duties by recognizing the presence of individuals, reacting to it in a non-disturbing, invisible way, fully integrated into the particular situation. Nearly synonymous concepts of disappearing computing or calm computing express the technology diffused into everyday objects and settings [Russell et al]. From the technological point of view, AmI bears ship to the conception of ubiquitous computing (UbiComp), the term firstly used by Mark Weiser in 1998 [Alcaniz and Rey; Bohn et al]. UbiComp is defined as the use of computers everywhere and is determined by interactions that are not channelled through a single workstation.

The AmI environment is characterized by merging of physical and digital space. It means that tangible objects and physical environments are acquiring a digital representation [Kameas et al]. The AmI environment is considered to host several UbiComp applications.

The AmI artefact (also smart object, smart device) is an element of the AmI environment that has got following properties and abilities [Kameas et al]: information processing, interaction with environment, autonomy, collaboration, composeability, changeability. Building of an AmI artefact from any common object consists of two phases: embedding hardware modules into the object and installing software. Hardware components are especially batteries, sensors, processors, wireless modules and screens. Software components are those of hardware drivers, networking subsystems, operating system, and middleware for integration of artefact in distributed systems. The AmI hardware builds on four components: distributed processing, hierarchical storage, tangible interfaces and ubiquitous communication. [Snijders] presents a three-level hierarchy of devices with different functionalities, designed to solve the energy constraint that is the determinative factor of any AmI application.

Technical features of UbiComp systems and the main tasks to be solved by AmI technological background are summarized e.g. by [Alcaniz and Rey]. The crucial research domains related to the AmI vision are suggested in [ISTAG 2005]. The main areas to be evolved are those of:

- development of necessary hardware, especially
  - smart materials that enable mass storage, emit light, process data, active and passive tagging or access to networks,
  - specific devices for particular applications, with limited processor and hard disk requirements and therefore of low cost,
  - sensor technology bridging the physical world and the cyberworld,
  - interfaces with a good display quality and responsiveness to user input, supporting natural interaction that combines speech, vision, gesture and facial expression,

- defining of new software architectures and appropriate software, mainly
  - invisible file systems, that allow user to access data under the principle of "produce one, present anywhere", but without knowing specific file names, locations, formats,
  - automatic installation mechanisms and migration of programs from one computer to another with ability of self-managing and self-adjusting, but without requiring fundamental changes in configurations,

- working on contextual awareness and personalization of information that is tailored to user's requirements and location observed by networks of sensors and cameras, status tracking, interactions, user modelling etc.,

- working on privacy issues, both theoretically (see [Lessig] for the concept of personal privacy in cyberspace) and practically in sense of encryption techniques to ensure security.

The concept of AmI is strongly motivated 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 in [Bohn et al], 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.

The societal acceptance of AmI vision depends on such features of AmI applications as ability to facilitate human contact, orientation towards community and cultural enhancement, ability to inspire trust and confidence, supporting citizenship and consumer choice, consistence with long term sustainability both at personal, societal and environmental levels, as well as controllability by ordinary people [ISTAG 2002].

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 [Gardner], or analytic, creative and practical intelligences offered by [Stemberg]) in different percentages. As [Bettiol and Campi] notices, 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.

The political impacts of the vision of AmI have their 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 the knowledge society. The new technologies must not be the cause for excluding some groups of citizens from society, but it must ensure universal and equal access to its digital 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.

3. AMBIENT INTELLIGENCE IN LMS: WHY?

The idea of AmI, still fresh and not too developed, is often communicated through illustrative scenarios that are related to certain domains. General scenarios of AmI applications in context of everyday life were offered in [ISTAG 2001]. Scenarios for a specific domain, the university that represents variable environment where many people interact with numerous systems and devices, were proposed in [Mikulecky and Olsevicova]. Students, teachers, managers, librarians, administrative staff and others need to access information and knowledge from different sources, according their individual needs and in different situations. These information and knowledge-intensive activities are limited by numerous constraints in terms of location, time and availability. University is a good place for demonstration of general AmI scenarios reusing UbiComp principles, push and pull technologies and new types of devices. A bit narrower, but interesting area, where the AmI vision can be examined and where significant results can be achieved, is the field of LMS. Following features of LMS are those that make LMS to be a good arena for fruitful exploring of the AmI vision:

- LMS enable experiments with different hardware solutions, because e-learning is realized on varied kinds of devices from PCs over laptops and handhelds to mobile phones. The AmI applications build on idea of new devices with innovated architectures and communication protocols and with software developed according new programming paradigms. As new and more sophisticated communicating devices will be invented and constructed, new impulses and new possibilities for more sophisticated, but also more user-friendly LMS usage can be expected.
- LMS are part of environment that consist of different digital and non-digital information systems, their full integration and communication with other systems is then naturally demanded and could be improved through suitable AmI solutions.
- LMS provide wide range of services, such as tools for educational e-content development, sharing and delivery, synchronous and asynchronous communication channels, utilities for evaluation of students’ performance and knowledge, tools for user records management and e-commerce modules. Here, the AmI applications can be involved in form of decision support systems and knowledge-based systems focused on appropriate utilization of educational strategies, scheduling systems or intelligent management of resources.
- LMS are used by good-sized and heterogeneous user groups (students, teachers, e-course designers) who differ in preferences, aims, needs, interests, personalities and experiences. Therefore it is a challenge to personalize all tools and services of LMS, reuse context information for intelligent customization of e-content or apply systems for monitoring of user activities with the aim to obtain and maintain user profiles. The high number of users promises to get relevant and heterogeneous feedback and meet unpredictable situations that would accelerate the development and improvements of particular applications. Also, the users of LMS are mainly students, i.e. people who are expected to be surrounded by the AmI environment in near future. It would be a quite good
In general, LMS provide services anywhere and anytime in the given environment, resembling thus somehow the idea of UbiComp, which seems therefore to be one of proper approaches for further development of LMS.

All the previous arguments, and certainly a couple of others, give us a good reason to experiment with LMS as with an ambient intelligence playground.

4. AMBIENT INTELLIGENCE IN LMS: WHERE AND HOW?

The human contact with LMS that consist of numerous variable activities can be understood from the perspective of optional application of different AmI sub-solutions. Here we present the main areas of meaningful utilization of AmI principles and technologies:

1. User identification and logging
The process of logging to the LMS is a simplification of the task of welcoming user by the environment around him or her. The identification mechanism, that recognizes the presence of individual, can be based e.g. on biometrics or voice recognition and can be enabled by electronic cards, RFID, mobile phones. This process has to involve fast loading of user profile, or the subprofile relevant to the device and the task. The process of logout has to be accompanied with storage of updated profile (if necessary).

2. Context-based services, customization, personalization and omnipresent monitoring
After logging, the presentation of content should be automatically tailored both to the particular user and to the device used for accessing LMS. This tailoring expects processing of data from user profile, deriving of recommendations etc. The context-based services have to build at least on following abilities:
   - to recognize and interpret information and knowledge needs of individuals,
   - to update users’ profiles with respect to information and knowledge needs, that newly appear, or that become irrelevant,
   - to customize information and knowledge delivery to language and format preferences given by user, including optional machine translation,
   - to exchange data with remote systems and external resources, with respect to security and privacy restrictions on both sides of communicating systems.

3. Application of new programming principles and AmI algorithms
The invisible, omnipresent, continuous monitoring of activities of users is one of AmI challenges. As the number of functionalities and tools inside LMS is limited, the limited list of activities performed by users can be expected, too. Nevertheless, the number of combinations of actions, their sequences and outputs mean that the task of their interpretation is non-trivial. There appears the need of new, efficient algorithms for processing terabytes of data collected about users, for updating profiles, for storing maximum data about the user’s context. Ambient programming principles (and languages) should simplify the development of flexible code, enabling parallel and/or distributed processing, independent on specific drivers and compilers, modular enough for optimal modifications and enhancements (see [Verhaegh]).

The number of users in LMS, spaced out in different e-courses allows experiments with AmI solutions in groups of users of different sizes: e.g. experiments with intelligent scheduling of learning activities can start in one e-course with 20 students and then can be repeated inside tens of e-courses with hundreds of students. That is how to obtain relevant data about the impacts of more extensive utilization of certain algorithm or technology in real conditions or of more intensive load of subsystems and their communication channels in situation when the technology comes on its edge.

4. Innovated hardware and new types of devices
Different electronic equipment is used in framework of LMS. Except of PCs there are also other personal digital devices, servers, data projectors, printers or copy machines. AmI applications and UbiComp systems can monitor and manage their functioning, control their communication, manage optimal usage of resources, organize repairs. The remote access to applications installed in centralized client-server model and central storage of data would mean that e.g. students could run programs on any type of device connected to the
university network and anywhere in the university campus, not only in the given computer lab. Printing jobs could be automatically sent to the most suitable printers (e.g. the closest or less loaded). Although the realization of this part of the AmI vision would request investments in a new infrastructure, involving a new communication layer interconnecting different devices, the AmI idea of cheap, narrowly specialized hardware makes the expenses less capital-intensive. In relation to software licenses, the application of pay-per-use model is meaningful.

5. Intelligent interfaces, processing implicit inputs and interactions
The interface is one of the most significant aspects of LMS. Intelligent, user-friendly, intuitively usable interfaces are one of the most challenging parts of the AmI research. From a world where one user is sitting in front of a single computer there is a shift to another world, with users living, working, and solving problems in an environment full of interfaces with various degrees of embedded intelligence, from very simple ones up to three-dimensional (3D) virtual worlds. The LMS evolution could clearly benefit from this. As an example of very complex and advanced intelligent user interface we can mention Active Worlds (see [AWEDU]). Active Worlds, is considered to be the most powerful web's virtual reality applications, with possibilities to visit and chat in 3D worlds that are built by other users. The Active Worlds Universe is a community of thousands of users that chat and build 3D virtual reality environments in millions of square kilometres of virtual territory. This can be certainly considered to be an interesting example of an intelligent 3D interface for a LMS evolution. Indeed, there is already a sub-world of the Active Worlds application, called the Educational Universe. It is an entire Active Worlds Universe dedicated to exploring the educational applications of the Active Worlds Technology [AWEDU].

6. Support of communication inside the community
Users of LMS are a kind of web community: students of e-course do not need to meet personally anytime, but they share interest in studied domain, they exchange ideas in discussions and chats. The AmI vision is often presented as an approach that will improve the life of an individual, but it should be also seen as something what will facilitate communication and improve interpersonal contacts.

7. Involving new types of smart learning objects
Learning in an intelligent environment occurs in a number of different contexts, so it is necessary to evolve LMS at least in the direction of context aware content providing. The learner might be interacting with a piece of knowledge, communicating or collaborating with other learners, using a particular learning path or elaborating the experience gained in the near past. In LMS, learning objects are cohesive pieces of learning material, usually stored in a database or in a digital library of learning objects (see, e.g. [Mikulecky2004]). A learner uses suitable learning objects, and creates time-ordered trails through them. In this context new types of learning objects with increased embedded intelligence could be useful, for instance museum artefacts or exhibits in the role of smart objects cooperating with LMS. Simultaneously, the introduction of the self-organization in computing (see [Staab et al] and its broad exploitation in the AmI area seems to be promising, here for instance in the role of self-organizing artefacts or learning objects. In this context, the idea of collaborating learning objects, that is learning objects capable of mutual communication as well as other important features, as adaptability or self-organization into suitable groups or time-paths, seems to be interesting as well.

8. Invisible file systems
Educational e-content stored in LMS is organized in files, traditionally using folder system. The folders and files are shared by e-course designers and teachers. The achievement of well-arranged system and its maintenance is difficult. The concept of invisible file systems would minimize the necessity to remember artificial paths to e-content, the need to construct and share acronyms and file names. Users, who access LMS from different devices, should always meet the same organization of digital e-content.

9. Affective computing
Affective computing is supposed to work with emotions of humans. [Alcaniz and Rey] explicitly talk about tutoring systems as typical applications for utilization of student’s emotional states by measurement of psychological signals. Therefore LMS are natural environment where the research in affective computing can be realized.
10. Privacy issues
The task of security and privacy is important anywhere where data about individuals are collected and processed. In LMS, personal data together with study results are stored to be at the disposal of teachers and administrative staff. New methods for protecting data in AmI environments are necessary, and their research should be one of highest priorities for the AmI research. Significant results in this direction certainly can contribute to building trust in new technologies among their potential users.

11. New business models
Commercial providing of LMS services opens the door to application of new business models, reflecting the ideas of real-time economy. Pay-per-use models, offered in relation to software licences, could be applied here, e.g. for getting experiences with its practical realization and with users’ response.

12. Interaction of AmI subsystems
The important fact is that the previously mentioned AmI sub-solutions can interact and can form the full-featured AmI environment. The exploring of this environment, whose all characteristics and total functioning cannot be easily predefined and anticipated, can bring new insights, utilizable in other more complex, less virtual (and therefore more expensive) AmI environments than LMS (e.g. intelligent houses, see [ISTAG 2001; De Carolis and Cozzolongo]).

5. CONCLUSION
The vision of Ambient Intelligence cannot become a reality from day to day. Its full realization can be achieved only through the sequence of simple, less sophisticated solutions, well tested, well proven and well accepted by the target audience. Learning management systems (LMS) that are used by thousands of users can serve as a good experimental area where some initial hardware and software AmI solutions can be realized practically. In the paper we presented the list of reasons that advocate this opinion and the list of directions that can be evolved in near future.

Our further research is devoted (1) to an evaluation of the importance as well as the feasibility of possible AmI solutions, and (2) to stepwise implementation of selected solutions into LMS.

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


