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Toward Smart Office Environments – Benefits and Drawbacks of Using Ambient Intelligence Technologies in Knowledge-Based Enterprises

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Abstract. More and more knowledge-based enterprises start to integrate Ambient Intelligence technologies into their business processes. While the usage of such technologies can lead to considerable benefits in a variety of business areas, the envisioned applications have to meet fundamental user needs, otherwise the negative side effects will overshadow the prospective benefits. This paper illustrates the benefits as well as potential risks of implementing Ambient Intelligence applications in knowledge-based enterprises and identifies the crucial aspects of successful system design.

Keywords: Ambient Intelligence, Ubiquitous Computing, Technology-Enhanced Environments, Smart Spaces, Intellectual Teamwork, Knowledge-Based Enterprises.

1. Introduction

High innovation pressure forces companies to adopt new technologies as early as possible [8]. Facing this permanent need for innovation, Ambient Intelligence technologies have the potential for providing competitive advantage, as they enable a variety of new products and services [25]. The concept of Ambient Intelligence (AmI) describes the integration of a variety of tiny microelectronic processors and sensors into almost all everyday objects, which enables an environment to recognize and respond to the needs of users in an almost invisible way [20]. Motivated by the promising developments of AmI applications in the production and retail sector [21], more and more companies are in the process of implementing similar applications in other business domains. Coroama et al. [9] predict that the current technical innovations in the area of Ambient Intelligence become an integral part of most business processes within the next few years. While until today, mostly manufacturing, logistics and retail companies used Ambient Intelligence technologies, more and more knowledge-based enterprises start to integrate Ambient Intelligence technologies in their business processes. The term 'knowledge-based enterprise' describes companies that rely heavily on knowledge assets, information exchange, employee-employee interaction and real-time decision making for successful functioning [16]. Typical examples of knowledge-based enterprises are consulting firms, companies in the area of business and financial analysis, law offices or research and development organizations. Employees usually work in temporary workgroups in order to accomplish intellectual and project-based work. These mostly non-routine and complex tasks show a high interdependence among team members, and therefore require an effective coordination and integration of individual activities. In order to cater the needs of such teams, knowledge-based companies need dynamic work environments, which provide effective networking capabilities, support the real-time flow of information and offer the ability to spontaneously scale and re-configure itself, based on changing business requirements [16]. Within the last years, several projects started to develop prototypes of smart office

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environments, that support office workers with a variety a different tasks, and dynamically adapt to the changing requirements of knowledge-based project work.

2. Benefits of Ambient Intelligence

With the amount of information technology constantly increasing and getting more and more ambient, future work environments are supposed to be intelligent, adaptive, intuitive and interactive [26]. Such smart office environments will enable office workers to communicate, collaborate and work in new and more efficient ways. The theoretical advantages range from increased work productivity through time-saving operations to higher work satisfaction through attentive and reactive environments. In the context of knowledge-based enterprises, the usage of Ambient Intelligence technologies can lead to considerable benefits in a variety of areas and on different organizational levels.

In a very general sense, Smith [22] expects groups of people to gain new forms of social power, ways to organize and coordinate their interactions, and exchanges just in time and just in place. Especially the advances in the area of interface technology will lead to considerable benefits on user level. Today, office workers usually work with single user devices, which require manual user input via standardized interfaces. With the emergence of Ambient Intelligence, those explicit and static interaction paradigms will be enhanced through new input and output concepts, like tangible user interface or ambient displays. Sensor-enhanced environments will enable implicit interaction mechanisms, which are unknown in existing work environments with traditional computational devices. By automating routine task and thereby releasing office workers from vacuous work activities, smart office environments bear the potential to increase overall job satisfaction.

On company level, the most important benefits, gained by the introduction of Ambient Intelligence technologies, are probably the optimization of existing processes as well as the ability to implement new and even more efficient business processes. Friedewald et al. [14] predict, that the ability of professionals to communicate with their peers, either in the same office or on the other side of the world, and to have an infinite world of information and intelligence to facilitate decision-making, will greatly expand with the emergence of Ambient Intelligence. In addition, smart environments, through which office workers could connect themselves with an increasingly remote and geographically distributed world, will significantly contribute to effective team work [2]. Such sensor-enhanced work environments will also enable new ways of dynamic resource planning and context-adapted time scheduling, based on real-time information from various, digital and non-digital sources. While tangible user interfaces provide a variety of direct benefits for employees, such new forms of interaction are likely to increase the efficiency of office workers, and thereby indirectly generate additional financial benefits for companies. Intuitive interaction mechanisms are not only reducing the everyday processing times, they also decrease the initial period of vocational adjustment to new office applications.

In addition to these intra-organizational benefits, Ambient Intelligence offers a variety of possibilities for facilitating business activities between different companies. Potential benefits include the support of communication and awareness in virtual teams as well as of planning and coordinating activities in cross-company projects, or the exchange of real-time data among companies in a supply chain.

3. Potential Risks of Ambient Intelligence

The integration of new technologies into existing business processes and work environments is always associated with high financial investments. When companies invest in new technologies and spend great amounts of resources into its integration, they usually expect a considerable increase in productivity, efficiency, and long-term benefits [1]. But in order for these benefits to occur, it is necessary, that the technology is used and also incorporated into the daily routines of the employees [19]. Nevertheless, empirical evidence shows, that one of the main reasons for low returns on investment of new technologies is the poor usage of the installed applications (see, e.g., [5], [6], or [11]). In most cases, the potential of the implemented applications is not fully realized, due to the unwillingness of users to accept and use the systems [3].

As just illustrated, Ambient Intelligence has an immense potential to revolutionize intellectual teamwork, bringing benefits for both employers and employees. But not all of these benefits are directly perceivable by users. According to Fleisch et al. [13], two groups of beneficiaries have to be distinguished. First, the user of the application, who gains an immediate benefit from the usage, for example, through the automation of inferior tasks. And second, the indirect user, mostly on management level, who can use the automatically captured information to conduct detailed analyses of user and business processes. Especially applications, which are based on the exploitation of user profiles, and where the advantage for the user can only be perceived indirectly, are likely to lead to serious concerns from employees. In this sense, von Locquenghien [28] concludes, that if users are not accepting this kind of external benefit, they might feel to be at the mercy of the system or even feel threatened by it.

From an economical point of view, the usage of AmI technology is likely to effect the efficiency of workers in two ways, directly through the reduction of processing times, and indirectly through higher work satisfaction. According to the human relation theory, which propagates a positive correlation between work satisfaction and performance, it is important to satisfy employees in order to get high performance in return [24]. This is also confirmed by the Two-Factor-Theory, which is based on empirical evidence gained in the so-called 'Pittsburgh-Study', where Herzberg et al. [17] used semi-structured interviews to ask over 200 accountants and engineers about pleasant and unpleasant work situations. They found, that only in very rare cases a single factor was connected with good and bad work experiences, which lead to the theory, that there are two different types of factors [29]. Based on this finding, they distinguish between motivators (or motivation factors) and hygiene factors. Motivators are intrinsic factors, which are related to the content of the work and lead to work satisfaction. In contrast, hygiene factors are extrinsic factors referring to the context of the work, which can help to prevent dissatisfaction. According to the Two-Factor-Theory it is essential to provide hygiene factors, to ensure an employee is not dissatisfied as well as motivators to encourage higher job performance. On the one hand, Ambient Intelligences bears the potential to increase work satisfaction by providing motivation as well as hygiene factors. The automation of routine task will release employees from low-level tasks, and thereby give them additional time to concentrate on intellectually challenging activities (motivation factor). In addition, adaptive office spaces can enhance the user's personal comfort within the work environment, and new ambient communication technologies can support social relationships within distributed teams. On the other hand, poorly implemented systems are likely to have considerable negative effects on work satisfaction. Herzberg et al. [17] found, that surveillance, for example, is one of the main factors for work dissatisfaction. Experiences with existing applications showed, that for example RFID, which is currently the underlying technology for most smart business applications, rises serious privacy concerns, when it is used to identify people.

As companies consist of hierarchical structures, some people might argue, that the acceptance of a certain technology by users might not be necessary, as its usage could be made mandatory for all employees. But experiences in the past showed, that mandatory usage of technology negatively influences the organizational climate. Srivastva et al. [23] analyzed over 500 empirical correlations studies and came to the conclusion, that the climate within an organization is positively correlated with individual satisfaction, and in most cases also with higher performance. Hence, it is important that employees freely and willingly adopt new technologies. From a current point of view, it is difficult to predict, whether smart office applications and services will be accepted by potential users. Experiences in the past showed, that whether innovations develop into something useful and acceptable can often only be decided with hindsight [18]. For example, Short Message Services (SMS) became very successful in Europe, while applications based on the Wireless Application Protocol (WAP) are hardly used [25]. Cantwell [7] conducted an in-depth study exploring, why some technical breakthroughs fail and others do not. Using several emerging technologies as examples, he showed that some new technologies were quickly embraced and held up as indications of human progress, while others were strongly rejected as examples of going a step too far.

4. Conclusion

Giving insufficient attention to the challenges posed by Ambient Intelligence technologies bears the risk that the negative side effects will overshadow the envisaged benefits [4]. For most companies, the key

motivation for investing in new technologies is usually to increase efficiency in order to maximize profits [9]. But by solely focusing on performance effects, other aspects of knowledge work are usually neglected. Besides performance, which is often used, as it is relatively easy measure, a variety of other factors are also effected through the implementation of new technologies. By focusing exclusively on performance, unanticipated beneficial or adverse consequences in other areas can outweigh short-term performance effects, and thereby determine the acceptance or rejection of the technology altogether [15]. While future office environments will be implemented using a variety of new technologies, the design of systems and applications should not be bound or driven by these technologies [27]. Instead of being determined by hardware possibilities and constraints, the design needs to be driven by humanistic needs and concerns [12], and accommodate the way people naturally interact [15]. If this does not happen, future office applications are likely to continue along the familiar path of current IT systems, which is characterized by increased complexity and inadequacy [10].

Therefore, it is most crucial to regard and involve potential users right away from the beginning of the design process and identify the requirements that potential users have in order to accept such intelligent offices. The design of smart office environments will have a considerable impact on the way people work and interact in these environments. The possibilities that arise from Ambient Intelligence will not only influence organizational processes, but also the way daily work is organized. This is especially relevant for intelligent office applications, as the potential benefits are not for 'free'. For their operation, intelligent user services rely on appropriate and sufficient information from users. This information may include their identity, usage patterns of systems or services, and preferences, and it might be collected by explicit and implicit means. Hence, the requirements to build trusted systems that perform exactly as they are expected to do, and that protect intimate data while still allowing easy access to it, are compelling.

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