Applying Context Metadata in Ambient Knowledge and Learning Environments – A process-oriented Perspective

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Abstract: Ambient systems sense their environment. Doing this, a lot of context related data is gathered and provided to other application systems. This data could be used to support and tailor knowledge and learning processes directly to the individual's context. Unfortunately, the concept of context is very broad and reaches beyond typical factors like location or time. With regard to integrated business, knowledge and learning processes additional context drivers must to be taken into account, e.g., the current business process determines the context in particular. In this paper we analyse various scenarios in three surgery clinics identifying a set of domain-specific factors that directly lead to process-oriented context requirements needed by a user-centred Ambient Learning and Knowledge Environment.

1 Introduction

The main objective of this paper is to derive a functional process-oriented metadata model to support the individual's knowledge and learning processes within specific business contexts, in particular for medical care.

The advent of modern information and communication technologies, especially mobile technologies, leads to the desire for personalized approaches within the fields of knowledge management and e-learning [Ya06; PB08]. As currently many learning environments are still static, it is a challenge to personalize and implement knowledge and learning environments with regard to the individual's context, e.g., place and time. Unfortunately, the concept of context is very broad and reaches beyond such typical factors [Sc02]. In the field of e-learning, context is also related to certain preferences, competencies as well as cultural aspects [PBV08]. The same for knowledge intensive business processes, whereby additional information related to a specific process must be taken into account. Applying ubiquitous and ambient technologies is one promising approach to provide various context factors. Such technologies sense their (physical) environment permanently. Doing this, a lot of context-related data could be provided to connected systems like learning management systems or knowledge management systems [BK08]. This data could be used to support and tailor more specifically knowledge and learning processes directly to the individual's context.

However, there is currently no standardized context specification [PB08]. Within the field of Ambient Intelligence and Ubiquitous Computing recent research mainly focuses on technical aspects, e.g., battery or power appliance, as well as (non electronic) entities belonging to the environment, e.g., tables or garment [Sc02]. As already mentioned, developing personalized Ambient Knowledge and Learning Environments demands a more user-centred perspective that is at each case directly related to the business process. In previous research for the field of e-learning, we have identified 160 influence factors as a base description for a variety of aspects, including countries, organisations, culture, technical infrastructure, legal systems [RP07]. Thereupon we developed a framework and procedures to include context information in the design and adaptation process of Ambient Knowledge and Learning Environments [PBV08].

The above mentioned approaches are very broad. They are intended as a basis which is adapted for a certain domain or problem situation. For this purpose, it is of vital importance to take the domain and the corresponding business processes into focus. Such a process-oriented solution has to be domain-specific as the processes vary enormously for different domains, such as production, service, support, medical care etc. The current process resp. domain directly determines the context, e.g., material management or sales, diagnosis or surgical procedure, etc. They also vary on the level of knowledge intensiveness. Therefore, we develop a domain-specific approach as a first step to derive a domain-specific process-oriented context metadata model.

The specific domain in this paper is medical care. We use this example as the domain needs a high degree of adaptation. Additionally, it is a focus domain for ambient learning and knowledge processes [BKR08]. To reduce the risk of complications for the patient and thus achieving a higher quality of treatment some hospitals already apply mobile as well as ambient technologies [BBF06; Mo06]. Besides, medical care is a complex service and its related processes are highly knowledge intensive. Therefore it is essential to take the specific working conditions, i.e., context, into account. Analysing various scenarios in three surgery clinics we identified domain-specific context factors to support medical staff with personalized ambient knowledge and learning processes. We will use these scenarios to derive the process-oriented context requirements needed by a user-centred Ambient Learning and Knowledge Environment.

The remainder of this paper is structured as following: we start with an introduction of the research fields which are integrated within this paper and which are closely related to the concept of context. Afterwards, we describe the design and methodology of our analyses of three surgery clinics. After an outline of the corresponding results we will present the derived process-oriented metadata model. We end with a summary of the main results and suggestions for further research activities.

2 Background and Related Work

With regard to the main objective of this paper, we will introduce the concept of context first (section 2.1). As most of the research work on context-awareness is inspired by the vision of Ambient Intelligence respectively Ubiquitous Computing we will also give a brief introduction into this topic (section 2.2). The proposed functional process-oriented metadata model will build up upon various a) approaches to adapt knowledge and learning environments as well as b) approaches to integrate business, learning and knowledge processes (section 2.3).

2.1 Context

The concept of context is widely used with very different meaning. Even within the field of computer applications and thus e-learning the notion is quite vague. Humans implicitly interact in context with their environments including information and communication technology [Sc02]. Following Schilit/Adams/Want such "*context-aware applications adapt according to the location of use, the collection of nearby people, hosts, and accessible devices, as well as to changes to such things over time* [SAW94]."

Context within so called Ambient Learning and Knowledge Environments (ALKE) in our understanding contains every influence factor on a knowledge-intensive process or a learning scenario but in turn is not specifically influenced within the design process (such as cultural aspects). Additionally, we understand those influence factors as crucial for successful personalization and adaptation of business processes. As an example, this means to define steps to fit learning environments to new contexts and additional factors influencing this process. The main idea is to identify and codify attributes which can automatically be derived and used in adaptive / adaptable systems. We have identified 160 influence factors (for a full description of the model, see [RP07]). The following Figure 1 shows the context blocks, i.e., the classes of contextual information.

Figure 1: Context blocks for e-learning [RP07]

Moreover, it is necessary to identify which context factors can be derived automatically and which factors can be semi-automatically identified during the run-time of a learning process. The following classification is used:

- *Context factor* is the influence factor to be considered in the design process
- *Identification type* shows how this factor can be derived. Three values are proposed. Automatic identification means that the factor can be derived automatically using an ambient or mobile technology. Semi-automatic means that the factor is to be identified during the process (e.g., by using information given by the actor). Manually means that the factor has to be determined by questioning the actor or using other sources in the design process.
- *Identification method / technology* define potential ambient or mobile technologies providing or deriving the information needed.

Table 1 illustrates how some of the context factors can be derived. However, for most factors ontologies and taxonomies have to be developed to map the relation of certain characteristics (e.g., national characteristics to location). For other factors, the availability of data (e.g., learner profiles) has to be checked.

Context Factor	Identification Type	Identification Mode
Culture: language	automatic	Language detection in mobile operating system
Geography: near location	automatic	Mapping of WLAN / UMTS cell
Actors: preferred learning style	manual / semi-automatic	Pre-assessment / usage of user profile

Table 1: Context Factor Classification

With regard to the adaptation, it is necessary to select context factors and to derive which factors can be collected automatically. The corresponding adaptation process can then differ in the degree of adaptation needs: from minor adaptation to a full re-authoring [PBV08].

2.2 Ambient Intelligence and Ubiquitous Computing

Context-awareness is a central issue to Mobile Computing as well as Ubiquitous Computing resp. Ambient Intelligence [SAW94; Sc02; BK08]. Mobile Computing is implemented with lightweight devices such as cellular mobile phones etc. However, such devices are not embedded in the environment, and cannot seamlessly and flexibly obtain information about the context [OY03].

The terms Ubiquitous Computing and Ambient Intelligence are often used interchangeably (Table 2). Extending Ubiquitous Computing the term Ambient Intelligence focuses on the architecture and more general aspects of how such vision could be integrated into human daily life [BK08].

Term	Focus	Area of Application
Ubiquitous Computing [We91]	Invisible network of numerous computers	RFID tags on objects offer a transparent logistic chain
Ambient Intelligence [IS03]	Networking of devices that collect and analyse information and derive autonomous actions	Ambient systems automatically identify the needs of the user and provide him with autonomous support

Table 2: Disambiguation

Based on a comprehensive literature review (c.f. [BK08]) we can indicate that the term Ubiquitous Learning is more commonly known as the term Ambient Learning. One probable explanation is that Ambient Intelligence represents more or less a specific European perspective on the vision of intelligent computer systems.

Yang defines Ubiquitous Learning or Ambient Learning as "*an interoperable, pervasive, and seamless learning architecture to connect, integrate, and share three major dimensions of learning resources: learning collaborators, learning contents, and learning services* [Ya06]". Thus, Ambient Learning focuses on how to provide learners with the right information at the right time in the right way [OY03].

Following Jones and Jo [JJ04] an Ambient Learning Environment (ALE) is a setting of omnipresent learning which takes place all around the student although the student may not even be conscious of the corresponding learning processes. Using an Ambient Learning Environment, a multitude of new learning situations arises and may be supported by the learners' surrounding context, i.e., by time and space as well as by what resources and services are available, or by the learning collaborators.

2.3 Adapting and Integrating Processes

A variety of systems is usually used within an enterprise, in particular in relation to knowledge intensive processes. Examples are systems for enterprise resource planning, human resources, authoring, learning management, knowledge management and document management systems. The main question is in our situation how context factors and, in particular, information derived from ambient systems can be related and integrated to personalize and adapt those systems, e.g., by data or application interface integration. This integration can be done in three steps [PB08]:

- Process Identification and Modeling: Processes in the context are modeled, including actors involved and systems used. Those should be modeled in a process model. This phase also includes the analysis of influence / context factors.
- Process Analysis: As a second step, processes should be analyzed concerning their personalization and adaptation needs. This means that it is analyzed which and how context information can be collected and how this can be taken into account.
- Process Redesign and Implementation: Based on analysis, the new processes should be designed.

As a basis, processes need to be modelled and analysed. We suggest to base this modelling phase on existing process reference models and standards to reduce the effort of modelling. An example of such a standard is ebXML as a reference model for general

business processes [UO06] or ISO/IEC 19796-1:2005 [II05, Pa07] for learning processes as well as development processes for learning environments. Based on this framework, we will derive a method how context factors are included in those processes. However, a variety of domain specific models can also be taken as a basis. The main challenge we address in this paper is how to adapt and personalize those processes and corresponding systems to ambient and contextual information.

3 Process-oriented adaptation and contextualization

The main goal of our approach is to show how contextual information is integrated in the design and development process for both, business processes and related information systems. According to the phase model presented in 2.3, the first step is to identify and adapt a process model and influence factors on this model. Therefore, it is necessary to identify general context factors (section 2.1). This set of factors needs to be adapted and extended regarding domain specific factors. For this purpose, we present our qualitative analyses of three surgeries to identify process-related context factors (section 3.1). Applying the corresponding results as well as the above mentioned approaches we develop the proposed process-oriented metadata model (section 3.2).

3.1 Scenarios

The survey was part of a research project that focused on the successful application of Ambient Intelligence in hospitals. We performed n=16 semi-structured interviews, following a qualitative research design, among the staff of the surgery departments of three German teaching hospitals. The transcripts of the interviews were coded applying the Open Coding method and the analysis was based on the principles of the grounded theory [SC98]. Table 3 gives a first introduction to various application areas as well as examples of the implementation of ambient support that were identified within the qualitative interviews (c.f. [BKR08]).

Application Area	Main Objectives
Patient Identification	• avoidance of incorrect treatment • data access
Patient Monitoring	• patient safety • treatment comfort
Collaboration	• filtering phone calls according to context
Clinical Pathways	• Alignment to and reminders of standard treatments
Object and People tracking	• patient safety • economy of time
Logistics	• efficiency • economy of time
Authentification	• security • economy of time

Table 3: Areas of Application

In the following we exemplify two scenarios that attest the application areas' knowledge intensiveness on different levels. To increase the corresponding process's efficiency various application areas of ambient technologies could find a use (Table 3).

Clinical Pathways: Starting point for any elective treatment is a referral from an external physician to the surgical clinic. The patient has to visit the corresponding physician. At this date, the exact surgical indication and the preliminary investigation are determined. After that possible risks related to the surgery will be explained to and discussed with the patient. The corresponding appointments are stored in a personal information software which is used as a group calendar, accessible for all eligible personnel. In general, all preliminary examinations are carried out ambulant on one day. These results are presented to the treating physician. Based upon these he decides on the further course of treatment. If all results are available and no further examinations are required, the patient can be operated as planned. Thus, the second appointment is stationary and the surgical intervention takes place. Therefore a bed has to be available for the patient at the station. This quite simple task is very often time consuming, because the capacity exceeds more than 100%. A reliable source to the current bed capacity mostly does not exist.

Collaboration: A physician at a hospital comes to an indication that he himself can not resolve satisfactorily. Applying a special device he can use a map of the hospital that depicts the position and status of some specialists [PBV08]. An integrated search function offers the opportunity to quickly identify colleagues available that can assist. Another physician, currently in a procedure, is also invited to join the corresponding group later. This group discusses the available facts. All members have direct access to the relevant patient data available, with regard to their preferred resp. available device. None of these doctors' can contribute a new approach. However, the physician delayed because of the procedure, fortunately recalls a similar indication some time ago. Since he does not remember the whole case, the attending physician searches the hospital repositories using the biometric data of his patient to identify related cases his colleague has dealt with. Based on the results the physicians can now decide on further examinations and treatments. Several days later all results are available. The disease could be identified and all group members finally get a report. The diagnosis and the further course of the disease are also documented, so the appropriate information in similar cases could be provided. Thus, the direct, personal networking between the parties increased.

3.2 Process-oriented Metadata Model

The next step is to develop a model for processes and corresponding information systems. We present a framework for process design which highlights the influence factors, both generic as well as specific for the domain of medical care. The model is based on the generic process framework described in [PB08]. This generic model was extended regarding medical care related processes and context factors. In the following, we show examples for three process classes: *domain-specific processes* for medical care, *knowledge management processes* and *learning processes*. All those processes can be designed to include and incorporate contextual information, in particular from ambient environments.

Process	Context Factor	Description
Diagnosis	Actor: Patient-ID semi-automatic / automatic	Patient identification aims to improve data access and the prevention of mistreatment. Through the use of sensors such as Radio Frequency Identification (RFID), the identity of a person may be verified with respect to the administration of medication, planned surgical intervention, or morning round.
	Actor: biometrical data semi-automatic / automatic	Relevant information such as pulse or temperature can be collected without the patient being in bed. Additionally, new information which have previously been problematic to generate, such as the degree of movement, can be collected in ambient environments. This information can be saved or analyzed.
	Geography: near location Automatic	Mapping of Sensors / WLAN / UMTS cell
Scheduling	Geography: near location Automatic	The use of sensors creates new possibilities in the field of tracking and tracing. In hospitals various problem areas – such as the planning and coordination of materials, instruments, operating rooms, beds and appointments – exist. The tracking of objects and persons with sensors results in time saving for searching activities. Besides, in emergency situations the nearest member of the medical staff can be alerted. In this way, saving time can save lives and reduce the risk of complications.
	Technical Infrastructure: sensor support Atomatic / semi-automatic	
Collaboration	Actor: physician-ID automatic / semi-automatic	Due to the team aspect of a treatment it is important to enhance communication between the involved persons. For instance, ambient systems could provide information on which staff is available and what they are doing. This could help to exchange knowledge or get a second opinion regarding a complicated decision (section 3.1). Such systems could also prevent failures in treatment and positively affect the treatment. This allows the detailed analyses of the processes and the continued optimisation of the collaboration between medical staff and helps to improve processes.
	Geography: near location Automatic	
	Content: Current Topic semi-automatic / manual	
Knowledge Sharing	Context: various factors	The main problem of knowledge sharing is to capture problem solutions for a certain situation. The effort to describe this is usually very high when only free text descriptions are used. Therefore, the full context can be captured using the status of environment variables, such as location, content, involved actors etc.
Knowledge Identification	Content: Topic Geography: location	Within this process, it is the main goal to capture relevant knowledge or to find actors who can share knowledge on a certain topic or problem. By using contextual information like content and location, it can be suggested whether a current work process is already available in the organization's knowledge base. This information also helps to identify people with expertise for certain problem areas.

Learning: Authoring	Content: Topic, Geography: location, actors	It is a main challenge to develop realistic learning scenarios. Context information can be used to design realistic problem scenarios for e-learning environments. In particular, these context information can be used to retrieve realistic data which can then be used for case studies of problem-oriented learning tasks.
Learning Process	Various context factors	Learning processes should be personalized and adapted to the learning. Within the learning process, learning scenarios should be adapted to learners' characteristics, such as learning style but also regarding cultural factors. In ambient learning environments, even more adaptation possibilities are given taking location factors into account.

Table 4: Simplified Process Analysis Framework

The outlined model is the basis for (re-)designing processes and adapted systems in the field of medical care. It is clear that it has to be further adapted for other situations than shown in our case study. However, it is the first time to present a process-oriented approach as guidance and orientation for designers and developers of adaptive systems using generic and domain-specific context information.

4 Conclusion and Further Research

In our approach, we have shown a generic approach how business, knowledge and learning processes can be designed and adapted based on process-oriented context information. The main idea is to inter-relate information on the context and in particular ambient context information with corresponding processes. We have shown how this approach is applied in a specific domain, medical care.

The benefits of our approach include a clear understanding of re-design of business, knowledge and learning processes as well as practical support for process and system designers. As usually context information is used in an isolated way, in most cases system components are re-designed but without considering necessary changes on the process level.

As a next step, the approach has to be extended and evaluated regarding two aspects: We will focus on the evaluation of the general approach in other domains such as information systems design. Another focus will be the validation of context metadata, in particular the usage of context information provided by ambient technologies, leading to a clear understanding of the consequences of metadata usage.

Our work is still in an early stage. However, the process-oriented approach is a way to combine process and data perspectives which is necessary to understand the integration and implementation of process-oriented context in organizations.

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