A User Interface Level Context Model for Ambient Assisted Living

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Abstract. Within Ambient Assisted Living (AAL) context awareness is an important feature of intelligent user assisting services. In this domain different requirements regarding context modeling can be identified that are not in the focus of current context models. One important aspect is the support of an end user interface for describing context dependent service behaviour. An inhabitant of a smart home needs to get and give feedback on context in a way that can be understood and handled without context modeling expertise. At the same time such simplified context description must be matched on the technical details of context sensing and context dependent service adaptivity. In this paper we introduce a layered context model for AAL which provides different abstraction levels. Therein we focus on model elements and concepts on the user interface layer.

Keywords: Ambient Assisted Living, Smart Home, Context Modeling, User Interface, Context Adaptive Applications

1 Introduction

The term ‚Ambient Assisted Living' (AAL) is used to describe technologies which help to extend the time where older people can live in their home environment by increasing their autonomy and assisting them in carrying out activities of daily life. This technology is based on the installation of a smart home environment which integrates into the human living space and interacts with the inhabitant. Technologies that are relevant in the application domain AAL come from the research areas 'home automation' and 'ambient intelligence'.

Research within Ambient Intelligence follows the goals of Ubiquitous Computing, which had been stated by Mark Weiser [1]. The computer should become invisible for the user. Instead the user should communicate with an intelligent environment naturally, which supports him in his goals. Natural interaction is achieved by providing interface support for language, movement, gesture and pointing [2]. Context awareness is also important to support natural interaction and to provide proactive services.

Published in:
Helal, S.: Smart homes and health telematics. 6th international conference, ICOST 2008: Ames, IA, USA, June 28-July 2, 2008; Proceedings. Berlin: Springer, 2008. (Lecture Notes in Computer Science 5120), pp. 105-112

Based on these key technologies AAL services can be provided which integrate into the human's living space and provide intelligent assistance. Examples for AAL services can be found in [3]. We have developed and tested a number of AAL services in our project 'SmarterWohnen' [4] together with a local housing company in the city of Hattingen, Germany. A number of developed AAL services have been deployed in apartments, which have been equipped with OSGi based sensors and devices. These services are now used by a number of selected tenants. They include water and gas leakage detection, intrusion detection, house automation and health related services like the supervision of vital parameters.

We have implemented a context subsystem as part of the service platform, which we have used in our projects. From our experience the development of context aware services for AAL puts special requirements on context modeling. A consistent modeling approach is needed that supports different aspects of using context: dynamic integration of context sensors into a smart home environment, definition of service specific context models and especially end user interface support for describing context dependent service behaviour. Current context modeling approaches do not fully meet these requirements. The concepts which we introduce in this paper focus on the user interface level and are part of the implemented context subsystem.

The rest of the paper is organized as follows. In the following section we discuss the related work. After that we identify the special requirements on context modeling from the view of AAL. Then we give a short description of our three-level context model which we use for building AAL services. Finally we describe the user interface level of the context model more in detail and its interdependencies with the lower levels and end with a conclusion.

2 State of the Art

According to Dey [5] context is "any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and application themselves". A context model is a formal description of the relevant aspects of the real world. It is necessary to abstract from the technical details of context sensing and to connect the real world to the technical view of context adaptive applications [6]. There are already a number of approaches for context modeling introduced into the context awareness community. In [7] an overview on actual approaches is given. For example context models based on simple name-value-pairs have been used for annotation of services with context information [8]. XML-based context models have been used for providing context profiles, e.g. the comprehensive structured context profiles (CSCP) [9]. Currently ontology based context models are discussed in the research community, e.g. in [10].

In [11] some requirements for context models in AAL are identified: application adaptivity, resource awareness, mobile services, semantic service discovery, code generation and context-aware user interfaces. Based on these requirements an extensible context ontology is introduced that is focused on four main aspects: user,

environment, platform and service. Based on that ontology services can be built that can adapt to changes along these four aspects.

One import aspect in context modeling for AAL is the provision of suitable user interfaces for the communication of context information to and from the elderly inhabitant. In [12] some requirements are identified that are specific from user interface design for AAL services. Especially the acceptance of such user interfaces from elderly people is a key point in AAL. In [13] a solution is proposed by providing a graphical programming language based on event-condition-action rules. Some technical skills are still needed in this approach which cannot always be presumed from elderly people.

3 Requirements

Requirements which have been identified in existing approaches are also valid for context modeling in AAL. In the following we will focus on requirements concerning context modeling on a user interaction level. First we describe a scenario in order to demonstrate these aspects. Then we identify the resulting requirements.

3.1 Scenario

This scenario is about elderly Mr. Bond who is moving into a smart home. The initial set of context aware AAL services is not sufficient for his needs. Therefore he is extending his set of services using an open service marketplace. In order to use the full functionality of his smart services, he is also extending the capability of the context environment by adding new context sensors. Then he is customizing the contextual behavior of the services according to his needs.

The initial set of context adaptive services for Mr. Bond includes a reminder service, which provides reminders depending on time-related context conditions. Mr. Bond adds a daily reminder to take his medicine at 8 pm. He thinks that it would be great if the reminder could be limited to those situations where he actually forgot to take his medicine. Mr. Bond tries to activate the health related context conditions. Since it is not supported by the context environment, the application is advising to add a new context sensor regarding the status of the medicine cabinet.

Mr. Bond thinks that it would be great to extend his set of AAL services with some functionality that could give him more control on the fancy smart devices in his department. He selects a house automation service from the AAL service marketplace and adds it to his application set. He starts to configure the new service. A number of smart devices are listed and also the actions that can be defined on them. Mr. Bond selects the lightings. He wants to have them turned on in the room where he is located, when it is dark and he is not sleeping. Mr. Bond gets informed that this service cannot be provided accurately, since there is no brightness sensor in his context environment. Because of the missing sensor also the functionality of detecting broken lights is not available.

Mr. Bond engages a service provider to extend his context environment with the identified context sensors. After the new context sensors have been integrated in the context environment Mr. Bond starts to reconfigure his services. Mr. Bond is now satisfied with his services and enjoys the electronic assistance of his smart home.

3.2 User Interface Requirements

Based on the scenario the following requirements regarding context modeling on the user interface level can be identified:

- The end user needs to define the context behaviour of his AAL service without high technical skills. The context model on this level has to abstract from the technical details and complexity from context modeling on the sensor and application levels.
- The selection of AAL services and the context dependent provision of their functionalities are limited on capabilities of the context environment. The user needs feedback on which functionalities can be supported and how to gain full support.

Additionally the following requirements can be identified:

- An inhabitant might from a privacy perspective be interested in information about what kind of context information is used by the application in order to provide the desired adaptability.
- In a ubiquitous environment where the behavior of services does not depend on explicit user interaction it is necessary to give feedback on the system's assumptions that lead to desired or possibly undesired actions. The environment has to provide means for the user to control and to make corrections to the assumptions about the relevant context.

Summarized, a user interface context model must provide means to communicate different aspects of context information to the inhabitant in a way that hides from the complexity of context modeling and is easy to understand and handle.

4 AAL Three Layered Context Model

In our approach we have organized the different aspects of context modeling into three layers: infrastructure, service adaption and user interface.

Requirements on the three levels differ from each other. Consequently context modeling and the implementation of a context model on the three layers is different. However, the context models on the three layers are not independent from each other. The three layers represent different abstractions from technical description of context to a user oriented representation.

In this paper we focus on the user interface level and its interdependency to the service adaption level. More information on the service adaption and infrastructure

layer can be found in [14]. In the following we give a short introduction into the relevant elements of the context meta model on the service adaption layer. Then we describe the context model elements of the user interface layer and show the connections between these two layer specific context meta models.

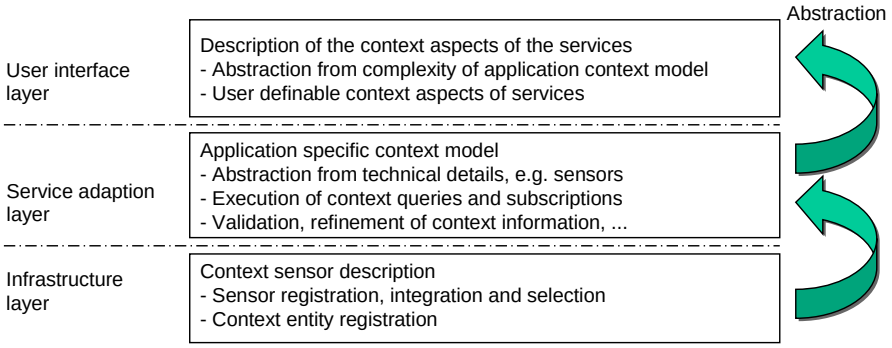

Figure 1: Three layered context model

4.1 Service Adaption Layer

The context model on this layer describes the context aspects that are relevant for the adaptivity of an AAL service. Our context subsystem provides methods that operate on this layer. Most context models identified and evaluated in [7] can be mapped to this layer. The meta model of our approach defines the concepts that are also common in most existing approaches:

- Context Entity: A context entity is named and represents a physical or conceptual object, e.g. person, building, electronic device, etc.
- Context Dimension: A context dimension represents potential common properties of context entities and relations, e.g. time, status, position, etc.
- Context Attribute: A context attribute describes a concrete property of a context entity or context relation by relating it to a context dimension.
- Context Relation: A context entity is related to another context entity by a uni-directional relation. A special relation is the generalization relation between context entities.

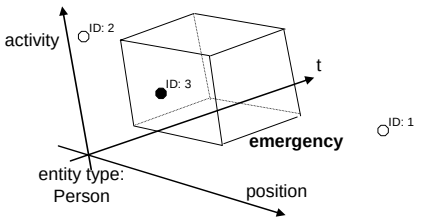

Figure 2: Named context subspace

All possible states of a concrete context model describe the valid context space. The definition of context subspace is an extension to the basic context meta model. A context subspace is defined by selecting the relevant context entities and relations of the context space and by setting constraints on their context dimensions. These subspaces are then named and represent a corresponding situation.

4.2 User Interface Layer

The context model of the user interface layer abstracts from the complexity of a service specific context model. In our approach we restrict context modeling on this layer to the selection and further refinement of already predefined situation descriptions. Predefined situations are represented by a situation taxonomy. Each element of the taxonomy additionally has a graphical representation and a textual description. At least the leafs of the taxonomy are associated to one named context subspace of the service adaption layer.

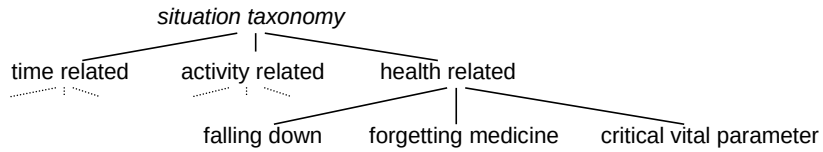

Figure 3: Example situation taxonomy

The graphical representation is used to give feedback on the system's assumptions regarding the relevant context. It can be shown highlighted in place of a detected situation. The inhabitant can select and deselect it in order to make manual corrections.

An AAL service can have a number of context adaptive functions, e.g. give a reminder on a specific situation. The adaptiveness of the function depends on the capabilities of the context environment, e.g. available context sensors. The inhabitant therefore needs feedback on limitations. In our approach meta information about the AAL service is given, which describe the context adaptive functions including the situations that can be applied on them. Based on this service description and the predefined situation taxonomy the support for these functionalities is identified. For each situation description of the function the service adaption context model is queried regarding the infrastructure support for the associated context subspace. The functional limitations depend on the results of the queries, e.g. limited situation support or even no service provision.

```
<situationTaxonomy>health</situationTaxonomy>
<contextAdaptiveFunctions>
        <function>
                <name>sendReminder</name>
                <forSituations>
                        <situation name=„time related“/>
                        <situation name=„activity related“/>
                        <situation name=„health related“/>
```

Figure 4: Example service description

User specific definition of the contextual behaviour of an AAL service also relies on the predefined situation taxonomy and the service description. The user selects a function that he wants to configure. In a first step the most general elements of the situation taxonomy that cover the set of situations from the service description are presented to the user. In a second step the user can navigate through the taxonomy of supported situations. While navigating he can then select a situation description which is associated to a context subspace. In a third step the user can further specialize the selected situation description. The specialization process depends on the meta information which is part of the service adaptation layer context model of the associated context subspace. In the following examples we assume a situation definition 'meeting people' which is described by a relation between context entities of the type 'location' and 'person'. The following specialization options are provided:

- Specification of the cardinality: If the context subspace consists of a relation between two or more context entities, then the cardinality at the relation can be specified. A specialization of that situation can be defined by setting the number of entities of the type 'person' within the relation to '>5'.
- Selection of specialized context entity: The user can select a more specialized context entity if it exists to a context entity which is part of the context subspace. An entity type 'neighbor' can be selected as specialization of 'person'.
- Setting constraints on context attributes: Depending on the related context dimension, constraints can be set on the selected attributes of a context entity or relation. The attribute 'age' of the entity type 'person' can be set to '>50'.

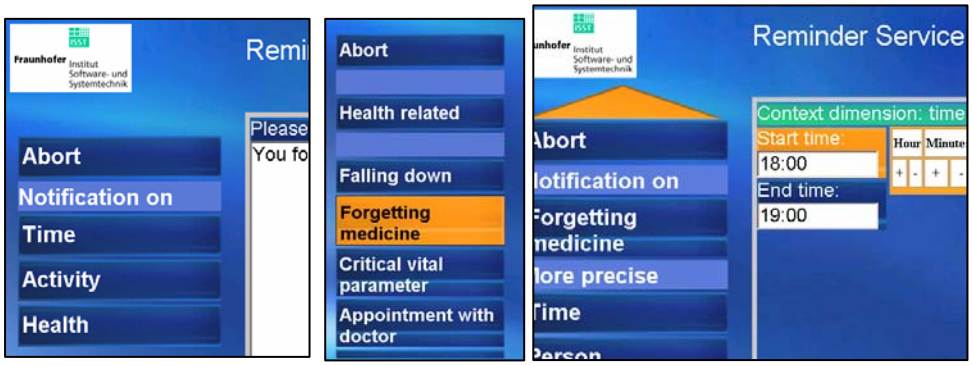

Figure 5: Interaction: situation taxonomy, navigation, further specialization

The user interface for defining the contextual behaviour depends on the situation taxonomy and the associated context subspace of the service adaption layer. It is part of our context subsystem of the smart home environment.

6 Conclusion and Future Outlook

Context modeling in AAL has to provide a consistent approach that supports different aspects of using context: integration of context sensors, service specific context

models and end user support. We have identified requirements towards context modeling from AAL and propose a three layered context model. The user interface layer provides an abstraction that allows the end user to define the contextual aspects of his AAL services. This abstraction does not provide the full expressiveness of the underlying layer, but it allows a guided definition process by selection and further refinement of already predefined situation descriptions. A final evaluation of the usability and the restrictions of this approach will be done in a following step.

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