Chapter 3
An Ontology-Based, Cross-Application Context Modeling and Management Service

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ABSTRACT
Context awareness is a key issue for applications within heterogeneous and networked environments. In terms of efficiency and reusability, such applications need to be separated from the problems of context gathering and modeling, but should instead profit from and contribute to cross-application context information. For this purpose, an ontology-based, cross-application context modeling and management service is required to provide appropriate support for the variety of conceivable application scenarios. Although there have been numerous approaches dealing with application-independent context management, none of them sufficiently supports the vision of cross-application context handling. Therefore, this paper presents CroCo, an ontology-based context management service that allows for cross-application context gathering, modeling, and provision. The authors successfully verified and tested the application independency and practicability of this novel concept within three different projects with disparate application scenarios.

INTRODUCTION
Context awareness and context-aware applications have been the focus of extensive research work in recent years. Accordingly, a number of solutions for context gathering and modeling have been suggested (Baldauf et al., 2007; Chen & Kotz, 2000) or already found their ways into practice, especially within the field of Location-based Services, e. g., Mobi.Ubiq\(^1\) services or Urban Mediator\(^2\). A context managing solution has to take account of appropriate support for context providers (e. g., software agents, applications,
or sensors, which supply context data) and context consumers (e.g., applications, which utilize context data for specific purposes).

Cross-application context management must allow diverse applications, application plug-ins, software agents, and sensors to act as context providers or consumers. Therefore, a corresponding context management service needs to offer a generic and flexible mechanism for dynamic registration of such agents. Registered context consumers should be able to fetch (i.e., query) relevant data from the service at any time (pull), or be notified if relevant data managed by the service has changed (push). Furthermore, context consistency needs to be ensured, e.g., with the help of appropriate consistency rules based on a confidence and reputation system for context providers, as well as a context history. Moreover, dynamic cross-application context management necessitates special care to be taken of security and privacy issues. Further challenges include the ambiguity and redundancy of context entities used in different domain models.

The majority of the proposed approaches exclusively fulfill the requirements of the according research projects and application scenarios, i.e., they support only specific context providers and context consumers or use a specialized domain model. Gathering, modeling, and supply of context information across application boundaries has still not been designed, implemented, and tested for and within heterogeneous scenarios. Thus, the vision of cross-application context awareness based on semantic technologies has not been fulfilled, yet. This vision could be fulfilled with the help of an application-independent, stand-alone context management component, which provides adequate interfaces for context providers and consumers to enter and access consistent, up-to-date context information for their particular application scenarios. In this article we therefore present a Cross-application Context management Service, called CroCo. It allows for cross-application context handling, with the help of a new concept of so called Domain Profiles. As a stand-alone context service, CroCo separates the modeling and management functionality from the context-aware applications themselves.

In the first section we discuss relevant work related to ontology-based cross-application context modeling. Afterwards, the design of CroCo is presented, followed by a discussion of the implementation details and usage scenarios to illustrate the practicability of our approach. Three “orthogonal” application scenarios are described: personal multimedia document management, adaptive co-browsing applications and context-aware user interface mashups. The last section summarizes this article and suggests future research directions.

Related Work

A lot of research has been carried out regarding context modeling and management (Strang & Linnhoff-Popien, 2004; Baldauf et al., 2007), especially in the fields of Adaptive Hypermedia (Hinz et al., 2007) and, more recently, Ubiquitous Computing (Bardram, 2005). In this research process the means for context representation have changed from basic key-value models to logic- and ontology-based models, which provide much better support for aspects like partial validation, disambiguity and applicability. We do not discuss these advantages in detail here, as this has already been extensively done, e.g., in (Strang & Linnhoff-Popien, 2004). In the following we shortly present related concepts for ontology-based context management.

Context infrastructures are usually similar in the components they consist of, which resemble the basic tasks of the system (e.g., management, inferencing and storage). However, they differ in important additional features, such as a Context History and Security support, as well as regarding their architectural style.

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