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ScienceDirect
Journal of Visual Languages and Computing
18 (2007) 420–439

Journal of
Visual Languages
& Computing

www.elsevier.com/locate/jvlc

Modeling context in mobile distributed systems with the UML

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Abstract

Context-awareness plays an important role in mobile distributed systems since it enables the adaptation of mobile devices to the users. However, one of the major challenges is the preservation of the users' privacy. Many different approaches of modeling the context of the user exist, but the incorporation of privacy restrictions into context models, which makes the protection of privacy apparent, is missing. This paper presents the Context Modeling Profile (CMP), a lightweight UML (Unified Modeling Language) extension, as a visual language for context models in mobile distributed systems. The resulting models embody metainformation of the context, i.e. source and validity of context information, and reflect privacy restrictions. The profile provides several well-formedness rules for context models and supports the development of context-aware mobile applications through an adequate visual modeling language. A case study is used to illustrate the approach.

Keywords: Context modeling; UML profile; Mobile distributed systems

1. Introduction

Present mobile devices possess high computational power, advanced user interfaces and wireless communication capabilities but still struggle with usability problems. The interface limitations of handheld computers result in the cumbersome usage of the devices and the hosted applications. Context-awareness is an interesting research topic in mobile

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doi:10.1016/j.jvlc.2007.07.001

computing because it enables technologies that can alleviate these problems and leverage the overall support of the user by the mobile device [1]. The service discovery in distributed systems can be improved by matching enriched service descriptions with the current context of the user, which increases the appropriateness of gathered search results [2]. Context-awareness is the foundation of context-based service provision, which enables the adaptation of the service provision to the individual service client [3]. The usage of context information facilitates the design of leaner user interfaces that require less user interaction and lighten the interface restrictions of mobile devices. Context-awareness also enables the development of applications that can adapt to the individual user. These context-aware applications can provide an increased personalization, proactive behavior and a more comfortable usage that result in a better support of the user. Hence, context-awareness can improve the overall capabilities of mobile devices and is considered to be one approach to realize smart devices.

Context can be defined as the set of information about the user himself and his environment [4]. Typically, the context of the user embodies information that represent the user's name, his location, his current activity and nearby persons [5]. This information can be incorporated by context-aware applications and facilitates the adaptation of the application to the current context of the user, resulting in an improved and more adequate support of the user. In the development process of a context-aware application, the developer has to specify the context information that are required by the application in detail such that the intended adaptation can be achieved. This means, the structure of the context, i.e. the set of required context information, the properties and the relationships between context information, has to be defined. The application developer has to build an application specific model of the user context, resulting in an artifact of the development process, the context model.

However, the context of a user is not composed by a durable set of information. In a mobile distributed system, which is constituted by the interconnected mobile devices of the system's users, the user context is changing irregularly due to the mobility of the user. The current location of a person represents an information about the user that changes frequently. In contrast to this, the place of birth of a user exhibits a static fact that never alters. The validity of context information represents *metainformation* of the context. The knowledge about this metainformation is essential if applications should be based upon a framework for context-aware applications. The services that are provided by the framework, i.e. the storage support of context information or the monitoring of the validity of the context, highly depend on this metainformation. Hence, the context model should not only provide the definition of the structure of the user's context but must also reflect the metainformation of the context.

Visual languages play an important role in software engineering because graphical representations of complex models are better understandable by and more apparent to human beings. The most popular object oriented modeling language is the UML (Unified Modeling Language) [6]. The UML provides different diagram types to visualize separate aspects of the modeled software system. The obtained separation of concerns increases the clarity of the visualized model. This paper shows how the context of context-aware applications for mobile distributed systems can be modeled by using UML class diagrams. The approach is illustrated by presenting a context-aware meeting system for mobile distributed systems as a case study. The requirements that are determined by mobile distributed systems and have impact on context modeling are explained and the