Federating Location-Based Data Services

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Abstract. With the emerging availability of small and portable devices which are able to determine their position and to communicate wirelessly, mobile and spatially-aware applications become feasible. These applications rely on information that is bound to locations and managed by so-called location-based data services. Large-scale location-based systems have to cope efficiently with different types of data (mostly spatial or conventional). Each type poses its own requirements to the data server that is responsible for management and provisioning of the data. In addition to efficiency, it is overly important to provide for a combined and integrated usage of that data by the applications.
In this paper we discuss various basic technologies to achieve a flexible, extensible, and scalable management of the context model and its data organized and managed by the different data servers. Based on a classification of location-based data services we introduce a service-oriented architecture that is built on a federation approach to efficiently support location-based applications. Furthermore, we report on the Nexus platform that realizes a viable implementation of that approach.

1 Introduction

Pervasive computing has drawn increasing attention in the past years. The vision is that smart everyday objects communicate and cooperate to provide services and information to users. Meanwhile, a multitude of applications has been developed. These applications cover different domains, such as tourist guides [9, 1], indoor information systems [11, 10] and smart environments [24], to name a few.

A variety of supporting infrastructures has been proposed, which facilitate the development of applications. However, these infrastructures mostly address a distinct application domain, such as context processing based on sensors [38] or providing application-specific context [9, 40]. Also, when new services, hardware, or environmental information such as maps become available to an application, other existing applications can not automatically use them. Interaction between different applications based

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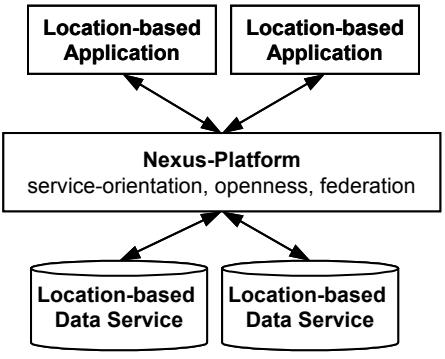

Fig. 1 Architectural Overview

on their context, e.g., identity, location, or state, is not possible if they do not rely on a common representation of this context.

Context-aware systems have attracted researchers in the past years starting from location-aware computing. Early work [39] considered context to be related to the location of users, the people nearby, and resources which can be accessed based on the spatial proximity. Depending on the focus of research projects, further definitions of context have been proposed. Context-aware applications use context information in order to adapt their behavior. The different context sources and characteristics of context information, e.g., type and representation, has led to a number of different approaches to supply applications with context information. Besides specialized approaches, e.g., the context toolkit [38] for sensor integration or the location stack for positioning systems [20], a generic approach based on a database-style management of context information has evolved that typically offers interfaces to query context information or to receive notifications on context changes.

For many context-aware applications, the spatial environment of the user is most relevant. So-called location-based applications, or location-based services (LBS), define a specific class of context-aware systems that adapt their behavior to the spatial context of the user, e.g., by providing local maps and navigational information. In this application area, there are already commercial solutions available, e.g., location-based information systems for mobile phones or car navigation services. They rely on spatial data that has previously been gathered and preprocessed to fit their needs. This data is expensive, because in many cases it has to be manually collected, edited and updated. Typically, spatial data is fused with traditional information from databases or web pages, augmented with a spatial reference, to form what is called the context model.

In the context of the Nexus project [31], we design and implement an open platform to manage such a context model. Based on an extensible set of so-called location-based data services, we introduce a service-oriented architecture that is built on a federation approach to flexibly and efficiently support location-based applications. All this is reflected by the coarse-grained architecture that is depicted in Fig. 1.

In this paper, we detail on that architecture approach and on how the Nexus project realizes that approach. In doing so, in the next section the characteristics of location-