Location Information Management in LBS Applications

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INTRODUCTION

The mobile computing advent brings a set of new applications that benefit from the constant need of information, diminishing communication costs and favoring the popularization of mobile devices, to reach an increasing number of users.

The mobility characteristic opens a new area for software applications. Associated to the mobility we have the location identification, which turns into a critical attribute, once it allows the development of a great variety of new services and applications. The systems that benefit from the use of that location information are named location-based systems (LBS); alternatively, these applications are also known as location-aware, context-aware, or adaptive information systems

More precisely, we can define LBS as applications that use the location information to supply services, based on this position context, to their users (Kupper, 2005; Schiller & Voisard, 2004).

The user location information makes available completely new and innovative service concepts, offering information to the user based on its own context (e.g., climatic information in the region where the user is located), increasing considerably the utility of these services. We know that location-based applications increase the services effectiveness, as they give a customized access to the data based on the user's preferences and on its actual position. This enhances the personalization content, giving several benefits to users and to the application developers.

In our daily life, several activities may use these services, like the emergency call centers, the car navigation services, and even location-based friend finder.

We may verify that, beyond the already cited characteristics and benefits, what also gave the LBS applications a growing perspective were the location techniques modernization and the mobile devices popularization, enabling the offer of more precise, objective, and useful information. In Shiode et al. (Shiode, Li, Batty, Longley, & Maguire, 2002), research shows the trend of LBS market and the market potential reserved to this class of applications that, each year, turns out to be more important to the users, becoming the area that dominates the applications for mobile devices. According to Sayed (2005), the forecast annual revenues for location-based services was estimated in US $3.3 billions for United States in 2006/2007, and in US $11.7 billions on the other countries.

In summary, we may say that the positional information has the potential to explore the user's geographical context as one of the most important variables for content and services personalization for mobile devices users.

BACKGROUND

The processes to manage data in location-based applications are especially challenging, as we need to deal with information as the user is moving from one place to other, in an environment with limited resources and also with heterogeneity. Diverse research areas contribute to ease the process of LBS application development to make possible to use all the spectrum of functionalities that can be implemented through these applications.

Developments in diverse areas such as databases, positioning technology, software engineering, and others, have been made, trying to ease the construction of LBS applications in a way to provide a large spectrum of services in this kind of applications.

Diverse works were proposed dedicated to developing frameworks that provide reuse in the development of LBS applications.

In Wolfson (1999), moving objects databases that store mobile objects location information are considered, especially the location information. The work concentrates on the query and update problems. For the update problem, an information cost model based on the communication cost and information accuracy is proposed.

Large-scale architecture for location services is proposed in Leonhardi and Rothermel (2002). The architecture presents a model of a location service (or generic API), defining the semantics of position queries (position), area queries (range), and proximity queries (nearest neighbor). To be scalable, it defines a distributed and hierarchical organization for the servers.

In Agre et al. (Agre, Akinyemi, Ji, Masuoka, & Thakkar, 2002), layer-based architecture is presented as basis for the construction of location-sensible systems. The paper defines a location service module (LSM) that is a middleware layer that simplifies the development of location-based services, as it gives a uniform interface that encapsulates the details related to the location information capture, and also gives several useful functionalities as location determination technology commutation, error estimation, location determination technology combination, and cooperative location determination

In Nord et al. (Nord, Synnes, & Parnes, 2002), an architecture for location aware applications is proposed, where positioning source devices, such as GPS, WaveLan, and Bluetooth, may be easily combined or intercalated to provide positioning services in a more precise way. The proposed architecture also supports a peer-to-peer communication, allowing the clients to know the others location, and also combining the location information with other contextual information.

Between several initiatives for the development of frameworks for location-based applications, we may highlight the ICING project (Kilfeather, Carswell, Gardener, Rooney, 2007). It has focused on multimodal, multidevice communications to provide enhanced services

Several location-based applications may be cited; among the most promising, we have the emergency call (Hargrave, 2000) (E911, 2001), navigation systems (ApontadorDuo, 2007), and support systems (Boondao, Esichaikul, & Kumar, 2003).

Also, there is an effort of standardization by the OpenGeoSpatial Consortium. The OpenLS (OpenLS, 2008) initiative, one of these efforts, is focused on the development of interfaces for the easiness of location information and other spatial information use over a wireless infrastructure. Its main aim is to integrate geospatial data and geoprocessing tools in location services, making available these functionalities for a large number of applications.

The management of location information is a central point in location-based applications development. Thus, all these applications share a common component, that is, in charge of the location information acquisition, communication, and storage, which we call location information management. This led us to the need for these functionalities reusing as a way to hasten the development process. In the next section, we describe an architecture that may be reusable, and a specification of a framework to permit the reutilization of the information location management.

LOCATION INFORMATION MANAGEMENT

Location information management is the management of location information of objects that may move, being in different locations in different times. This is an important aspect for several applications (Wolfson, 2008) such as fly-through visualization, context awareness, augmented reality, and cellular communication.

In the context of cellular communication systems, the location management problem has two main problems: point query to locate a cellular user that must be located, and point update to set the new cell that the user is when he/she moves beyond its original cell boundary. The problem, in this case, is restricted to how frequently it updates, and how to search a database of location records. For more information on this specific topic, see Pitoura and Samaras (2001).

In general, location-based applications, the problem is much broader. We need finer resolution, possibly with queries on the current, past, and future location, and triggers are very important; all these based on sets of objects. Actually, we see that a common approach for LBS applications development is to build a separate, independent location management component for each application. That results in significant complexity and duplication of efforts. Thus, as stated in Wolfson (2008), we need to develop location-management technology that addresses the common requirements and serves as a development platform.

To model the location of mobile objects, a commonly used approach is to model the location as a pair composed of location information (l) and time stamp (t) that is gener-