13 Location-Aware Services and its Infrastructure Support

Y. Chen and D. Liu
IBM China Research Laboratory

13.1 Introduction

With advances in wireless Internet and mobile computing, location-based services (LBS) have emerged as a key value-added service for telecom operators to deliver personalized location-aware content to their subscribers using its wireless infrastructure. Besides telecom operators, more and more service providers, such as public wireless LAN (PWLAN) providers, enterprises, etc. are developing and deploying location-aware services for consumers and employees to gain more revenue and productivity. These location-aware services providers (LASPs) are facing both technical and social challenges, such as positioning in various environments using different locating mechanisms, location tracking, information delivery models, privacy protection, and developing innovative LBS applications to achieve more business impact and value, among others. It has been realized that a flexible and resilient middleware should be built as the enabling infrastructure to support different players, so that service provider can efficiently and effectively develop and deploy LBS applications, and support innovative location-aware applications quickly. The location-aware infrastructure should address key challenges in location-aware computing as identified in [1], such as technology-independent location sensing, end-to-end control of location information, tracking and predication, and other research challenges involving geospatial information processing and human interaction with these information.

To address these challenges from a middleware infrastructure point of view, a location operating reference model (LORE) is developed to capture the location operation semantics from a layered perspective, where richer location operation semantic is modeled at a higher layer. The presented location operation semantics addresses many issues, for example, how to retrieve the location data, how the location data are modeled, how to fuse location from different location sources, how to query the location data, how to use tracking mechanism to deliver intelligent location-aware notification, etc. In addition to the semantics, two other important dimensions in location-aware computing, privacy protection and management, are also covered by the LORE model. Based on the LORE model, different components of the location-aware infrastructure are built to meet the requirements of different layers and expose APIs to developers to build other components that could plug into the model. In the following sections, several key components of the LORE infrastructure are introduced to show how issues of the
location-aware computing addressed and how the composition of components could facilitate the development of various location-aware services.

The chapter is organized as follows. In Sect. 13.2 the LORE model and the infrastructure are presented. Three key components of the infrastructure, location server with common adapter framework (CAF), moving object database (MOD), and spatial publish/subscribe engine are introduced in Sects. 13.3, 13.4, and 13.5, respectively. Section 13.6 outlines the related works, while Sect. 13.8 summarizes our studies and presents future directions.

13.2 Location Operating Reference Model and Infrastructure

Figure 13.1a illustrates the LORE model proposed to capture the semantics and management issues required by building location-aware services. The LORE model includes four domains: operation semantics, management, privacy and security, and agent.

13.2.1 Operation Semantics Domain

The operation semantics domain includes layered components that, from bottom to top, are positioning, modeling, fusion, query, tracking, and intelligent notification. The layered components explicitly describe the dependencies among components, i.e., the upper component uses the functionalities exposed by lower components to build more advanced functionalities. The overall functionalities provide the capabilities for location-aware applications requiring rich location operating semantics.

The *positioning component* addresses the issue of technology-independent location sensing, i.e., how to get the location information of target objects via specific positioning mechanisms. Technical neutral positioning requires that the positioning component interface with heterogeneous positioning equipment and expose a uniform virtual positioning mechanism for other components. The component has to deal with two different modes of positioning: server based and client based. In server-based mode, the location of the target object is measured and calculated on the server side, for example, the GSM networks could determine the subscriber’s position by the cell where the mobile phone is being served. In client-based mode, the device does self-positioning, e.g., a device with GPS can determine its location. The major difference between the two modes is how the positioning component retrieves the location information. In the server-based mode, the component pulls the location from server by accessing the location interface (e.g., LIF [2] interface) exposed by the server. In the client-based mode, the device always pushes the location to the positioning component, because it is difficult for client to have a location interface. Two positioning modes require the positioning component to support both push and pull models.