Location-Based Services – A Data Management Perspective

Hardware-Related Trends
Several trends in hardware technologies combine to provide the enabling foundation for mobile e-services, termed m-services. These trends include continued advances in miniaturization of electronics technologies, display devices, positioning devices, and wireless communications. Another trend is the general improvement in the performance/price ratio of electronics hardware. Perhaps most importantly, positioning technologies are becoming increasingly accurate. Real-time positioning can be achieved with either GPS, technologies that utilize the wireless communication infrastructures, and other technologies, e.g., indoor positioning systems. It is hard to foresee which specific positioning technologies will be used under which circumstances.

Infrastructure
Visionaries expect that the coming years will witness a global computing and information infrastructure that contains billions of wirelessly connected devices, most of the embedded devices. Many devices will offer so-called Location-based Services (LBSs) to their users, who are always connected in any location, outside and indoors. Example LBS devices include these:

- mobile-phone terminals,
- personal digital assistants (PDAs and handheld computers),
- position-aware cameras and sensor-enabled wrist watches, and
- in-car computing and navigation equipment.

Internet-Based Services
The development of LBSs paves the way to an emerging range of qualitatively new types of Internet-based services. These types of services are of limited interest in today's traditional context of fixed-location desktop computing. The following categories of Internet-based location-enabled services may be envisioned:

(i) traffic coordination, management, and way-finding;
(ii) location-aware advertising;
(iii) integrated information services, e.g. tourist services, that enable the completion of complex tasks;
(iv) safety-related services that, e.g., bring higher quality of life to user with medical conditions;
(v) locator services that enable users to find family members or friends – the Telia service FriendFinder enables a group of individuals to locate their friends; and
(vi) location-based games that merge virtual and physical spaces – e.g., the BotFighters game, by the Swedish company It's Alive, gives players points for finding and "shooting" other players via their mobile phones (using SMS or WAP). Only players close by can be shot. To enable the game, players can request the positions of other nearby players.

General Location-Based Service Scenario
One may envision that moving objects use services that utilize location information. The objects disclose their positional information to the services, which then use this and other information to provide specific functionality. The combined information is used for analyzing the user interaction with the services. The services also use such information about the users' behaviors

for mass-customization, so that each user receives a service customised to the user's current specific preferences and needs. In addition, the accumulated information can be used for delayed modification of the services provided, and for longer-term strategic decision making and analysis.

Data Management

As always, large geographic databases, be they used in either GIS or for LBSs, demand good design, standardized data models, and high performance. LBSs give rise to new challenges, namely that of handling the frequent transmission of position information from the moving objects to a central database. Oracle and other database manufacturers produce system that handles geographic objects, but which do not contend well with very frequent updates of geographical positions. There are modelling problems and performance problems. One line of research aims to offer database representations of the positions of the moving objects, taking aspects such as position uncertainty, and new geographic indexing techniques under development address the latter problems. Like in most information systems, data or information management represents a central and difficult challenge in information systems providing LBSs to their users.