

2.2 Location-Awareness and Location-Based Services

Looking at the set of potential context variables, many existing platforms concentrate on *location* and *time* as these variables usually are the most important inputs to describe a specific situation [40]. In addition, there exist techniques and sensors to capture these variables effectively by applications. Nearly all currently available computers know the current time. With the declaration of the *Full Operation Capability* of the *Global Positioning System (GPS)* in 1995, researches also assume the ability of a mobile device to detect their locations (even though GPS is not always available, e.g. indoors).

The ability to react to locations, the *location-awareness*, can be considered as a special form of context-awareness. Corresponding services are called *location-based services (LBS)*. Even though the term *services* is traditionally used for networked services, the term is also used to describe applications that work offline such as car navigation systems. For such applications, the more general term *location-based* or *location-aware applications* can be used. Table 2-1 shows some quotations explaining the term location-based service and application.

Table 2-1. Some definitions of location-based services and applications

<i>Network-based services that integrate a derived estimate of a mobile device's location or position with other information so as to provide added value to the user. [120]</i>
<i>Location based services are business and consumer services that give users a set of services starting from the geographic location of the client. These services offer the possibility to users or machines to find/locate other persons, machines, vehicles, resources and also location-sensitive services, as well as the possibility for users to track their own location.[...] Most location based services will include two major actions: 1. Obtaining the location of a user 2. Utilising this information to provide a service. [57]</i>
<i>The term location-based services (LBS) is a recent concept that denotes applications integrating geographic location (i.e., spatial coordinates) with the notion of service. Examples of such applications include emergency services, car navigation systems, tourist tour planning, or "yellow maps" (combining of yellow pages and maps) information delivery. [153]</i>
<i>Location-based services will allow mobile users to receive personalized and lifestyle-oriented services relative to their geographic location. [118]</i>
<i>Business and consumer 3G [Third Generation] services that enable users or machines to find other people, vehicles, resources, services or machines. They also enable others to find users, as well as enabling users to identify their own location via terminal or vehicle identification. [166]</i>
<i>There are two categories of mobile location-based services and applications: location-aware and location-enabled. The principle behind mobile location services is simple: Location-based services use the geographical location of an individual on the move to provide personalized information, transactions, or interactions. This kind of location-aware dynamic content provides the foundation for a variety of wireless services: navigation, traffic, concierge, and emergency services, "friend finder," and mobile commerce applications. Mobile location-based services (MLS) also offer significant potential for businesses and government organizations seeking to increase efficiencies and cut costs by tracking their mobile personnel and assets more effectively. Location-enabled applications add the important aspect of the device's location on top of existing applications. [...] Consumer examples include instant messaging, chatting, matchmaking, and so on. Enterprise examples are sales force automation and customer relationship management. [163]</i>

Location-Based Mobile Phone Services

In addition to GPS, several technologies promoted the development of location-based services in the last years. One of the most important milestones was the introduction of digital mobile phone networks. In Europe the *Global System for Mobile communication (GSM)* started in the 1990s, which is meanwhile used in more than 190 countries in the world. The mobile phone was the first mobile and widely available computing platform. Cellular phone infrastructures are often viewed as the most promising platforms for location-based services – very often, people mean by location-based services only location-based *mobile phone* services.

Although widely available, mobile phones currently have some serious disadvantages:

- Very often, they do not contain any positioning hardware.
- They offer only very limited computational power.
- Standardized development platforms are not widely available.

As there is no positioning system available, the mobile phone network roughly determines the user's location with the help of the communication cells (see section 3.4.1 on page 28). As standards for data communication, first the instant messaging service *SMS* (*Short Message Service*), later *WAP* (*Wireless Application Protocol*) and *i-mode* were available. Mobile phone providers offered several location-based services so far – often with only moderate success.

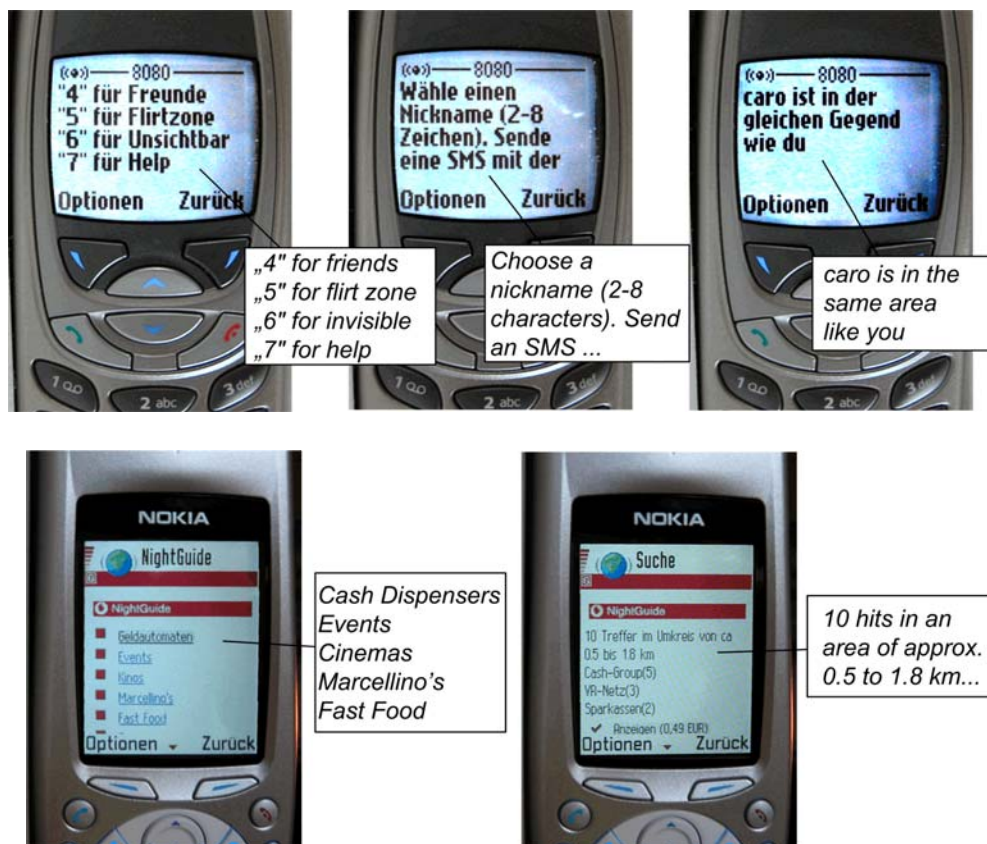


Fig. 2-1. Location-based mobile phone services in Germany

Fig. 2-1 shows two existing location-based phone services in Germany. The upper screens show the so-called *friend zone* – an SMS-based service to locate other mobile phone users. Every interaction requires to send an SMS which has to be coded according to a simple textual protocol. Users can ask the mobile phone network to find out the location of *friends*; each friend has to give explicitly the permission to be tracked by other users. As a second service, a user can broadcast an SMS to all friends in the nearer area.

As WAP becomes more and more available, more convenient services are possible. Fig. 2-1 (bottom) shows the *Nightguide* service which allows to look up hotels, cash dispensers, cinemas, restaurants etc. For this, the service provider administrates a database of the corresponding so-called *points of interest*.

Some of the problems of mobile phones mentioned above are more and more eliminated:

- Manufacturers start to equip mobile phones with GPS receivers to determine the mobile user's location with high accuracy.
- Mobile phones become more and more capable to run powerful applications. So-called *smart phones* have the computational power of PDAs, which now have the capability of desktop computers delivered three years ago.
- Platforms for developing software on mobile phones become available. Early versions of the *Java Micro Edition* [165] were mainly used to run games, but newer versions provide a reasonable functionality for networked mobile phone applications. For smart phones, platforms such as *Symbian* [63] or *PalmOS* [129] allow the development of applications in C/C++.

With the introduction of *UMTS*, experts expect a huge market potential of location-based services in mobile phone networks in the future [167].

Classification of Location-Based Services

In the last years, such services have also been created for other platforms than mobile phones. Fig. 2-2 shows some examples: a fleet management application and navigation applications (outdoor and indoor).

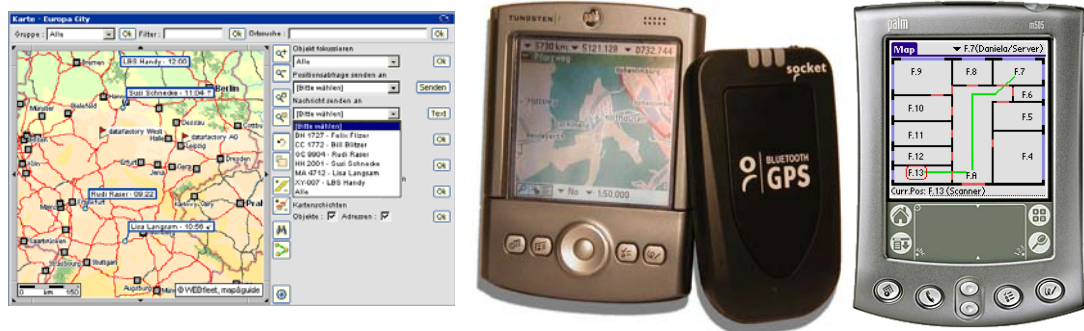


Fig. 2-2. Fleet management and navigation applications

Even though location-based services are available for years, a widely accepted classification does not exist. Table 2-2 is a compilation of several classifications found in literature [14, 78, 90, 156, 167].

Table 2-2. A classification of location-based services

Category	Description	Examples
Location-based information services	The mobile user requests information about the location	Local weather forecast, navigation, local maps, local bus schedules
Points of interest	The mobile user looks up stationary objects or facilities in the nearer area	Finder services (restaurants, hotels etc.), service lookup (e.g. printers)
Discovering other users	The mobile user looks up other users in the nearer area	Friend finder, flirt finder, games

Table 2-2. A classification of location-based services (continued)

Category	Description	Examples
Tracking services	A (potential stationary) user looks up the location of a mobile object or person	Fleet management, tracking children, tracking assets
Assistance services	A service centre receives the location of a mobile caller who needs assistance	Emergency calls, breakdown services
Messaging and announcement services	Mobile users receive a message from another user broadcasted to a certain area	Local advertisements, messages to nearby friends
Trigger services	A mobile user receives a trigger when entering a certain location	Location-based reminders, traffic warnings, weather warnings
Location-based billing	A user is charged according to his or her location.	Toll billing, home zones

The following characteristics of location-based services can be distinguished:

- **Business characteristics:** For service providers, the underlying business model is of important interest. Location-based services can be distinguished by the classes *C2C*, *C2B*, *B2B*, *B2C*, *C2G* and *B2W* ('B': business, 'C': customer, 'G': government, 'W': workforce) [90]. According to the idea of peer-to-peer networking, a service can also be established solely by the users without any service provider.
- **Privacy characteristics:** Whenever the location of a user is part of the service, legal and privacy issues have to be considered. Even though the law in many countries does not explicitly declare how to treat a user's location, it is mostly considered as *private*. For the mobile network it is imperative to know the user's location, but third parties should not reveal locations of private users nor should generate movement profiles. Some location-based services explicitly transfer location information from one user to another (e.g. assistance services). For such services, security mechanisms have to be introduced.
- **Technical characteristics:** As an important classification, *push* and *pull services* can be distinguished. This classification does not only affect technical aspects of the service implementation, but also the type of interaction: pull services reply information on demand, whereas push services deliver information to mobile terminals based on an event or trigger condition. Push services require low-level support of the underlying network and end-user device. A further distinction considers the *state* [78]: a service is stateful if it maintains a state across multiple service requests, otherwise stateless. A final issue is the required *accuracy* of the underlying positioning system. Some services require only moderate accuracy whereas other services (especially assistance services) require accurate location information [14, 156].

Table 2-3 summarizes the characteristics of the respective location-based service categories.

Table 2-3. Location-based service characteristics according to [14, 78, 90, 156]

Category	Business model	Pull vs. push	Location accessible by third party	State	Required accuracy
Location-based information services	C2B	Pull	No	Stateless	<1 km
Points of interest	C2B	Pull	No	Stateless	<1 km
Discovering other users	C2C	Pull	Yes	Stateful	<200 m
Tracking services	C2C, B2B, B2W	Tracking entity pulls	Yes	Stateful	<200 m
Assistance services	C2G, C2B	Push	Yes	Stateless	<20 m
Messaging and announcement services	C2C, B2C	Push	No	Stateless	<1 km
Trigger services	C2C, C2B, B2C	Push	Both possible	Stateful	< 500 m
Location-based billing	B2C, B2B	Push toward billing infrastr.	Both possible	Stateless	< 500 m