Foundations of LBS

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1. Foundations of LBS

Learning Objectives

- After completion of the lesson you will be able to identify the components and participants of a given LBS application.
- You will be able to describe the interaction of the components, which is the processing chain of a service request.
- Further you will be able to list and explain five types of context awareness.
- You will be able to list three levels of adaption and give two examples on every level.

Introduction

Mobile phones and the Internet have revolutionized the communication and with it the lifestyle of people. An increasing number of mobile phones and Personal Digital Assistants (PDA) allow people to access the Internet where ever they are and when ever they want. From the Internet they can obtain on one hand information on events (cinema, concerts, parties) and on the other hand information on places (city maps, restaurants, museums, hospitals).

Let us consider the example that somebody wants to take a dinner in a restaurant and is therefore searching a restaurant in the Internet. A useful approach to prevent that one gets as search result every restaurant web-page on the world one could restrict the search by adding further search criteria. A good choice is the city where the mobile user is (position), the actual time (evening) or a special type of restaurant (Chinese or Greek).

Such kind of restaurant search with respect to position and time can be done by use of a Location Based Service (LBS). Thus, one can define that:

A Location Based Service delivering a map of the environment and the position of the hiker.

LBS Definition 1:

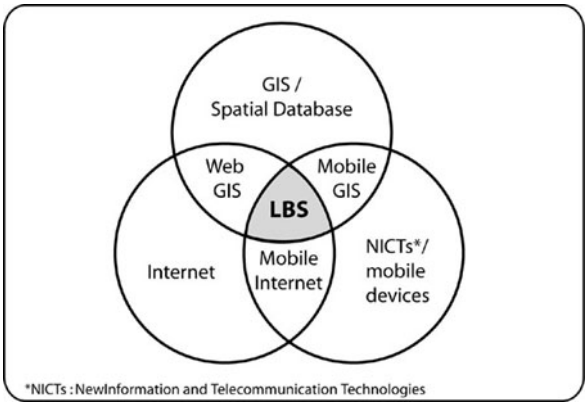
> LBS's are information services accessible with mobile devices through the mobile network and utilizing the ability to make use of the location of the mobile device. (Virrantaus et al. 2001)

A similar definition for LBS is given by the international OpenGeospatial Consortium (OGC, 2005):

LBS Definition 2:

> A wireless-IP service that uses geographic information to serve a mobile user. Any application service that exploits the position of a mobile terminal. (Open Geospatial Consortium 2005)

These definitions describe LBS as an intersection of three technologies (see figure). It is created from New Information and Communication Technologies (NICTS) such as the mobile telecommunication system and hand held devices, from Internet and from Geographic Information Systems (GIS) with spatial databases (Shiode et al. 2004).



LBS as an intersection of technologies (Brimicombe 2002)

From a historical point of view location based information are not a new thing which came up with the invention of mobile phones. (2001) emphasize that position specific information is also transported on one hand in a person-to person communication by post-it notes and graffiti. On the other hand methods to locally inform a mass-audience are posters (e.g. of concerts in the town) or simply traffic signs, which submit navigational information. These communication forms are usually one way communications. LBS give the possibility of a two way communication and interaction. Therefore the user tells the service provider his actual context like the kind of information he needs, his preferences and his position. This helps the provider of such location services to deliver information tailored to the user needs.
In the following four subsections we will try to answer the mayor questions which may appear if somebody likes to know what Location Based Services are:

- **What are Location Based Services?**
- **How is it useful?**
- **What is special about it?**
- **How does it work?**

1.1. What are LBS?

Learning Objectives

- You will be able to identify the basic components of a given application.
- You will be able to formulate questions from given LBS keywords which help to analyse LBS applications.
- Given a service you will be able to identify if it is a push or a pull service and explain your decision.

In the following subsections some major characteristics and definitions on LBS will be given. We will discuss the relation between GIS and LBS and give some Keywords which are useful to describe the LBS Technology. Later the basic LBS components are introduced shortly. Finally we will explain what a *Push* and a *Pull Service* is.

1.1.1. GIS and LBS

The Illustration from "*Brimicombe*" (Brimicombe 2002) shows that GIS and LBS have some particular similarities. Such common features are the handling of data with positional reference and spatial analysis functions (LBS-services) which give answers to questions like:

- “Where am I?”
- “What is near by?” or
- “How can I go to?”

But LBS and GIS have different origins and different user groups as described by (2004).

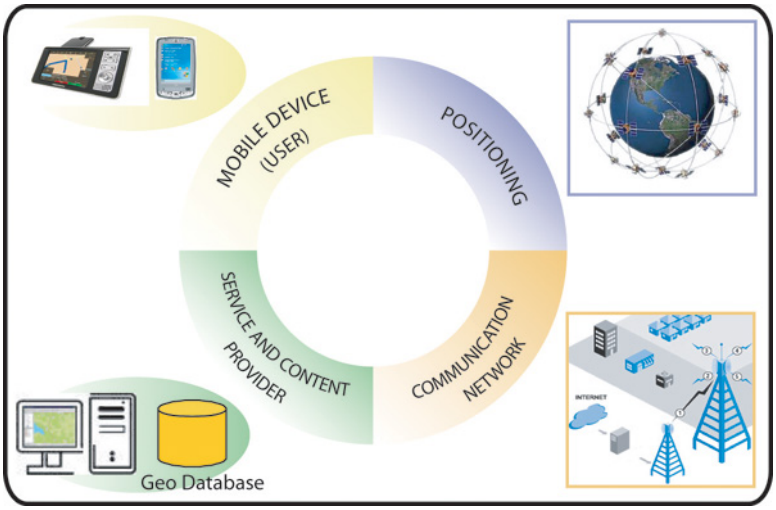
	GIS	LBS
evolution	during several decades	quite recently
user groups	experienced users	non-professional users
functionality	wide collection of functionality	limited functionality
requirements	extensive computing ressources	restrictions of mobile computing environment (computational power, small battery run time)

(2004) analyse that GIS have been developed during several decades on the basis of professional geographic data applications. Whereas LBS were born quite recently by the evolution of public mobile services. With respect to user groups, GIS can be seen as traditional “professional” systems intended for experienced users with wide collection of functionality. Furthermore GI-Systems require extensive computing resources. In contrast, the LBS are developed as limited services for large non-professional user groups. Such LBS applications operating with the restrictions of mobile computing environment like low computational power, small displays or battery run time of the mobile device.
If you don't know what Geographic Information Systems (GIS) are, have a look on this GIS e-learning Project **www.GITTA.info**

1.1.2. Components

If the user wants to use a location based service different infrastructural elements are necessary. In the figure the five (4+1) basic components and their connections are shown: *Mobile Devices* [3], *Communication Network* [4], *Positioning Component* [5], *Service and Application Provider* [6], and *Data and Content Provider* [7].

[3] A tool for the user to request the needed information. The results can be given by speech, using pictures, text and so on. Possible devices are PDA's, Mobile Phones, Laptops, ... but the device can also be a navigation unit of car or a toll box for road pricing in a truck.



The basic components of an LBS: User, Communication Network, Positioning, Service Provider and Content Provider

For a more detailed discussion on the components see also the Unit **How does it work** and the subsequent LBS Lessons.

1.1.3. LBS Keywords

LBS applications can be characterized by a number of keywords and related questions:

Mobile User:

Who or what is mobile? The mobile object can be a person or a device like a car navigation system. (see further **How is it useful?** and (2004))

Mobile Activities:

What Questions and Problems have users? Such questions do emerge from the user actions: locating, navigating, searching, identifying, event check. A further question with respect to actions is the (spatial) scope of activities. According to (2004) we can distinguish three types of spatial scope:

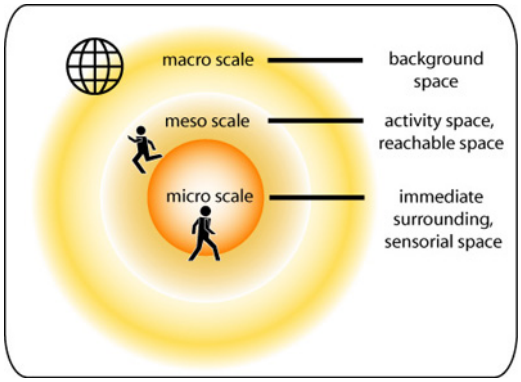
1. Macro scale: Do I need an overview?
2. Meso scale: What is reachable for me?
3. Micro scale: Where am I?

[4] These LBS component transfers the user data and service request from the mobile terminal to the service provider and then the requested information back to the user.

[5] For the request of LBS the user position has to be determined. Here one distinguishes between tracking (a network determines your position) and positioning (position self evaluation). Usually the user position is obtained either by using the mobile communication network or by using the Global Positioning System (GPS). Further possibilities to determine the position are local networks like Bluetooth or WLAN, active badges or radio beacons. The latter positioning methods can especially used for indoor navigation like in a museum. If the position is not determined automatically it can be also specified manually by the user.

[6] The service provider offers a number of different services to the user and is responsible for the service request processing. Such services can be the calculation of the position in a more global context, to find a route, to search the yellow pages with respect to position, find information on a specific object of user interest (e.g. a bird in wild life park) and so forth.

[7] Service providers will usually not store and maintain all the information which can be requested by users. Therefore geographic base data and location information data will be usually requested from the maintaining authority (e.g. mapping agencies) or business and industry partners (e.g. yellow pages, traffic companies)



The spatial scope of activities. (Heidmann et al. 2003)

Information:

What is needed to answer a user question and how is it done? A model of information retrieval is needed to answer the user questions. Such an information process model contains a model of possible questions, defines Queries of geographic base data and location information data, and specifies possible answers (see animation below).

Search and Spatial Analysis:

Which methods and algorithms are suitable for real-time information query in the Internet and spatial data analysis? Further question are: ”How to integrate data and information of different scale, quality, data types, prices?" "How is the data availability and actuality?"

User Interface:

Is a person using a PDA or mobile phone or something else? How can the user or (navigation) system formulate his needs and can make them more concrete after obtaining an overview?

Visualisation:

How is the information, returned from LBS, communicated to the user? Speech, text, pictures, pictograms, maps, lists,..

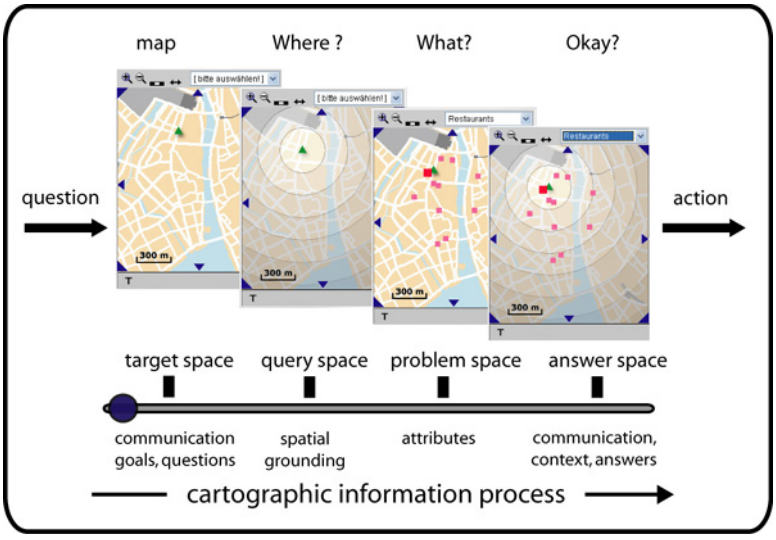
Technology:

How are service requests and data transferred between user and service provider? Where are the data stored? Which services are provided? Which positioning technology is used? ...

These questions and characteristics will be considered in more detail in the following units and lessons.

The Information Process

The animation below shows the cartographic information process if a user asks for shops or restaurants close to his position. Moving the slider from left to right will give you the processing stages of the result map.



Question and answer model for cartographic information processes adapted adapted from Heidmann 1999 (Reichenbacher 2004)

1.1.4. Push and Pull Services

In general one can distinguish two different kinds of location services considering if information is delivered on user interaction or not:

Pull services deliver information directly requested from the user. This is similar to call a website in the Internet by fill in its address in the web browser-address field. For pull services a further separation can be done into **functional services**, like ordering a taxi or an ambulance by just pressing a button on the device, or **information services**, like the search for a close Chinese restaurant (Virrantaus et al. 2001).

Push services deliver information which are either not or indirectly requested from the user. Such push services are activated by an event, which could be triggered if a specific area is entered or triggered by a timer. An example for an indirectly requested service is a news service subscription which contains event information with respect to the actual city. A not requested service could be advertisement messages if a specific area in a shopping mall is entered or warning messages if weather conditions change (e.g. hurricane warnings). Since push services are not bound on previous user interaction with the service, they are more complex to establish. Here, the background information like user needs and preferences have to be sensed by the push system.

1.1.5. Self Assessment

Food for Thoughts: LBS Keywords and Context

Try to identify elements of the LBS keywords (Mobile Users, Activities, Information, Interface, Visualisation and Technology) for the following application:

- A car driver wants to go to the next gas station using the car navigation system.
- Charles wants to meet his friend next to the train station. He`s looking on his mobile for the way to the train station by tram.

Only pictures can be viewed in this version! For Flash, animations, movies etc. see online version. Only screenshots of animations will be displayed. [link]

1.1.6. Summary

In this Unit we gave a basic introduction to Location Services:

- We showed that LBSs have its roots in GIS technologies, communication technologies and the Internet containing possibly information we are looking for.
- We made clear that LBS's consist of five basic components: whereas one can group the last two into one component. These components will describe in more detail in the following sections and lessons.
    1. Mobile Devices
    2. Positioning
    3. Communication Network
    4. Service Providers
    5. Content Providers
- Apart from the components we gave a number of keywords which carry on to questions we should consider if we want to analyse mobile applications.
- Finally we explained how push and pull services can be distinguished. Pull services sent information on user interaction (asking for the next restaurant) and push services deliver information without user interaction (advertisement in a shopping mall, weather warning).

1.2. How is it useful?

Learning Objectives

- You will be able to distinguish between user activities and demands.
- You will be able to list four types of activities and state how they relate to given goals.
- You will be able to describe existing Location based services in terms of their application field, their accuracy needs and their room of usage (indoor or outdoor).

Introduction

Where am I? Where are my friends? What is here around me?
The idea behind LBS is to answer these and other questions. If designing LBS the user's needs on information have to be met in order to make the services useful.
When individuals find themselves in an environment with which they are unfamiliar, their behaviour and needs are largely predictable, whether in their own country or abroad, in a vehicle or on foot. People need to find somewhere to eat, perhaps a pharmacy, somewhere to obtain cash, a taxi stand, and so on. When abroad, there are additional requirements: finding the local tourist attractions, getting around, locating a hotel and a foreign exchange. When driving, there may be other requirements, such as help with finding a route through an unknown city or details of breakdown services. Today, an ill-prepared traveller (who does not consult the Internet, buy a guide book, pick up information at the hotel or airport check-in, book in advance, etc) wastes a lot of time, and will not receive much help from his or her mobile phone. (Dru et al. 2001)
This Unit will first clarify what typical user actions are and what type of information therefore is needed. Second usefulness of LBS is shown by giving some examples of LBS which are already operational or will be soon.

1.2.1. User Actions

Associate User Actions and Goals
Activities during mobility, however, will often have spatially related actions embedded. These actions result out of user questions or desires. The most obvious question is to know where the user himself of somebody or something else is **(locating)**. Users may search for persons, objects or events **(searching)** and they ask for the way to a location **(navigating)**. Other questions ask for properties of a location **(identifying)** or they would try to look for events at or nearby a certain location **(checking)**.
Associate the user desires with the corresponding actions

User Actions and Questions
Using LBS involves a set of different basic actions. Five **elementary mobile actions** with a reference to geo-information are given above: locating, navigating, searching, identifying, and checking (Reichenbacher 2004). Checking uses not only geo-information but involves also time, since it refers to state of entities or events as well.
An activity is a sequence of actions conducted by a human being aimed at achieving a certain objective (Nardi 1996). This objective could be solving a problem or a task. In mobile situations objectives are for example orientation, finding persons or finding the way to an object. The objectives can also be expressed by questions which the user of LBS wants to have answered. The following table relates the elementary mobile actions with the questions they try to answer and further to basic geospatial operations that are used.

!	action	questions	operations
	**orientation & localisation** locating	where am I? where is {person|object}?	positioning, geocoding, geodecoding

	**navigation** navigating through space, planning a route	how do I get to {place name| address| xy}?	positioning, geocoding, geodecoding routing
	**search** searching for people and objects	where is the {nearest|most relevant| &}{person| object}?	positioning, geocoding, calculating distance and area, finding relationships
	**identification** identifying and recognising persons or objects	{what| who| how much} is {here| there}?	directory, selection, thematic/ spatial, search
	**event check** checking for events; determining the state of objects	what happens {here|there}?	

user activities (Reichenbacher 2004)

Information for searching, identifying and checking

The two basic actions *locating* and *navigating* mainly rely on geospatial information. Searching, identifying and checking however need a bigger variety of different information. Additionally to the geospatial information also other types of information are needed:

- Comprehensive **static information** are mainly contents such as a yellow pages. Such information stays constant over a while and could of course also be retrieved via other media (book, newspaper, map, TV, internet, etc.)
- **Topical information** is information that may change while the user is on the move. In such a case the information checked previously from other media may no longer be valid. Examples of such topical information are traffic information, weather forecasts, last-minute theatre ticket deals, or on-line chat.
  In addition to topical information, the users will need guidance on how to proceed in the changed situation. For instance, a train schedule as such can be obtained elsewhere but once on the move, the user will need information on delays and estimated arrival times.
- Additionally **safety information** has key importance, e.g. actual information on the state of the roads or hiking trials, weather changes, danger of falling rocks, etc. Car drivers or boaters also need information in emergency situations, e.g. roadside help in a situation when the car breaks down
- Far too often users are seen as passive information consumers. However, letting the users participate and provide their opinions and recommendations could enhance many services with **personal information**. An example therefore would be notes on good places to go on mushroom foray

In general users wish to maintain control over information content, delivery (*pull* [15]/*push* [16], text/picture/video) and personal privacy and security. Security issues are shortly discussed in the subsection on **context**.

[15] The user asks actively for information or assistance.

[16] That the information is delivered without asking to the LBS user.

1.2.2. Examples

Categories of location based services

There exist a broad range of different location based services. The following animation gives an overview on the main categories of LBS applications and names some examples. For every example additionally information on the positional accuracy needs and the service type (push or pull service) is shown. This listing does not claim to be complete and is certainly growing over time.

The different service categories differ in the needed *accuracy* [17], the *environment* [18] they are used in and the information *delivery* [19]. High positional accuracy denotes an accuracy within 50 meter while a low accuracy is worse than 300 meter.

Different fields of LB-Service applications

Given below is a bunch of LBS applications. Have a 5 minutes view on some of them to get a deeper impression of the possibilities which LBS delivers.

A - Emergency Services

One of the most evident applications of LBS is the ability to locate an individual who is either unaware of his/her exact location or is not able to reveal it because of an emergency situation (injury, criminal attack, and so on). E.g. motorists are often unaware of their exact location when their vehicle breaks down. With the exact location automatically transferred to the emergency services the assistance can be provided quickly and efficiently. This category includes public and private

[17] The accuracy of the positioning method ...

[18] The environment in which a LBS is usually used

[19] The way how information from a LBS is retrieved or delivered to the user.

emergency services for both pedestrians and drivers. While public emergency services for calling out fire-fighters, medical teams, etc., are currently being mostly regulated by public organisations the emergency roadside assistance for drivers appears to be one of the most promising of the assistance services in terms of operator revenue.

A 1 - Enhanced 911 (E911) mandate

Enhanced 911 (E911) mandate: The E911 mandate of the United States government aims to improve the quality and reliability of the emergency services by locating wireless 911 (U.S. emergency phone number) callers. The requirement was to ensure 50 metre accuracy for 67% of calls (150 metres for 95% of calls) for handset-based solutions, and 100 metres for 67% (300 metres for 95%) for network-based solutions by October 2001.

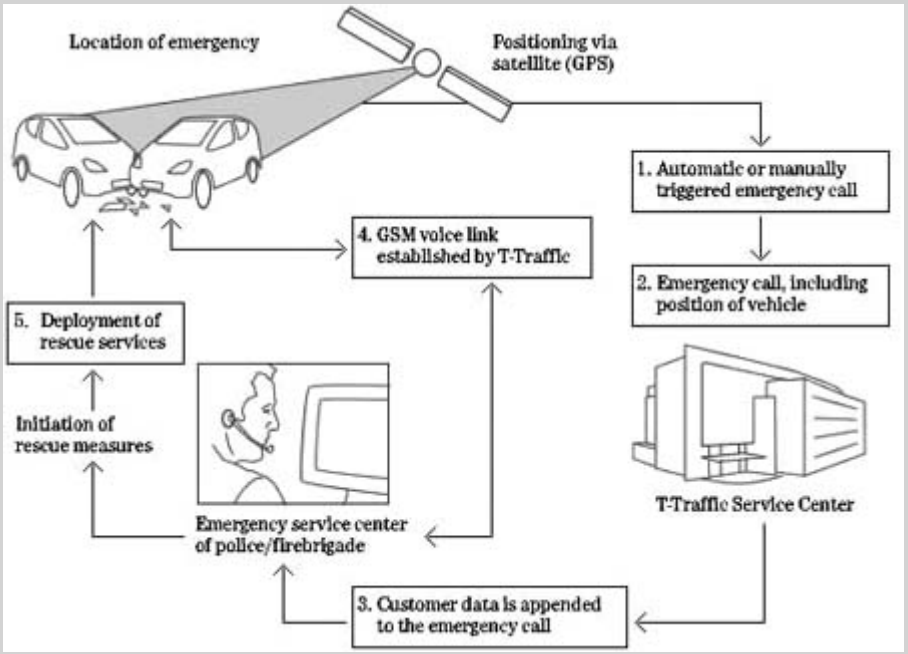
A 2 - SAR – Search and Rescue

SAR – Search and Rescue: This example is probably one of the oldest examples for a location based emergency system. Radio beacons e.g. on marine vessels or small personal beacons transmit radio signals in the case of an emergency. The systems range from small beacons with only normal radio signals (as homing signal for rescuers or to geo stationary satellites) up to beacons which transmit their actual GPS position via satellite to the emergency services.

COSPAS-SARSAT System Overview (NOAA Satellite and Information Service)

A 3 - Automotive assistance and theft protection

Automotive assistance and theft protection: Some upper class car manufacturer offer already special automotive assistance via LBS. In case of a car breakdown or an emergency the car driver can directly call via the on-board computer the emergency service and transmit his actual position. Some systems already foresee even a transmission of the error analysis by the on-board systems. Other systems foresee the transmission of the cars actual position in the case that it gets stolen. It is only a matter of time that all these systems will be available for all cars.



Mercedes-Benz TELEAID (T-Traffic)

B - Navigation Services

Navigation services are based on mobile users. Needs for directions within their current geographical location. The ability of a mobile network to locate the exact position of a mobile user can be manifested in a series of navigation-based services:

B 1 - Navigation service

Navigation service: By positioning a mobile phone, an operator can let the user know exactly where they are as well as give him/her detailed directions about how to get to a desired destination. In most of the current car navigation systems, other information than routing functionalities and the road databases are not in the mobile device. The user gets the pre-calculated route via the mobile network connection.

Car Navigation (Tomtom)

B 2 - Traffic management

Traffic management: Coupled with the ability of a network to monitor traffic conditions, navigation services can be extended to include destination directions. Such traffic management services take account of current traffic conditions (for example, traffic congestion or a road blocking accident) and suggest alternative routes to mobile users.

B 3- Car-park guidance systems

Car-park guidance systems: Finding a car park can be very time consuming and creates often additional traffic hold-ups. A time critical service which knows the available car parks and the position of the requesting car can assign the next available car park and guide the car to it.

B 4 - Indoor routing

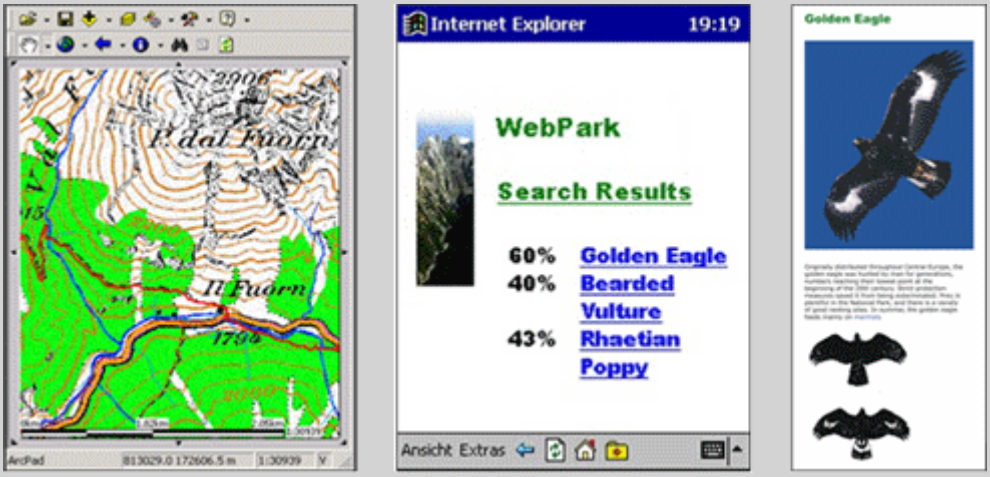
Indoor routing: The possibility to provide detailed directions to mobile users can be extended to support indoor routing as well. For example, users can be assisted in their navigation in hypermarkets, warehouses, exhibitions, and other information rich environments to locate products, exhibition stands, and so on.

C - Information Services

Finding the nearest service, accessing traffic news, getting help with navigating in an unfamiliar city, obtaining a local street map – these are just a few of the many location based services. Location-sensitive information services mostly refer to the digital distribution of information based on device location, time specificity and user behaviour. The following types of services can be identified within this category:

C 1 - Travel services / tourist guides

Travel services / tourist guides: Services such as guided tours (either automated or operator-assisted), notification about nearby places of interest (monuments etc.), transportation services, and other services that can be provided to tourists moving around in a foreign environment (city, national park).



WebPark LBS with presentation of habitats of different plants and animals (Edwardes et al. 2003)

C 2 - Mobile yellow pages

Mobile yellow pages: The application of mobile yellow pages that provide a mobile user, upon request, with knowledge regarding nearby facilities is another example of information services. This service can be combined e.g. with a navigation service. A common example would be a restaurant or hotel finder which shows the way to the destination.

C 3 - Travel planer for train, bus etc.

Travel planer for train, bus etc.: According to the actual position and the desired destination the user gets the next station and the departure times.

C 4 - Infotainment services

Infotainment services: Information about local events, location-specific multimedia content, and so on, can also be provided to interested users.

C 5 - Shopping guides

Shopping guides: They help to search for the best prices at the local area.

C 6 - Mobile blackboards

Mobile blackboards: Allow users to leave messages at certain locations and which can than be read if someone other passes by. This can be simple messages, but also hints or restaurant critics etc.

D - Advertising Services

Furthermore, mobile advertising has gained significant attention because of the unique attributes, such as personalization, that offer new opportunities to advertisers to place effective and efficient promotions on mobile environments. There are various mechanisms for implementing mobile advertising coupled with LBS. Examples are mobile banners, alerts (usually dispatched as SMS messages) and proximity triggered advertisements. Due to the potentially intrusive nature of mobile advertising services, it is generally acknowledged that users will have to explicitly register to receive such services perhaps in exchange for other benefits.

D 1 - Location aware SMS advertising

Location aware SMS advertising: SMS messages with advertising for nearby events or offers. Subscriber of such services get reimbursement. E.g. for each received SMS the user gets points which he can exchange against other bonuses.

E - Tracking and Management Services

Tracking services can be equally applicable both to the consumer and the corporate markets. One popular example refers to tracking postal packages so that companies know where their goods are at any time. Vehicle tracking can also be applied to locating and dispatching an ambulance that is nearest to a given call. A similar application allows companies to locate their field personnel (for example, salespeople and repair engineers) so that they are able, for example, to dispatch the

nearest engineer and provide their customers with accurate personnel arrival times. Finally, the newfound opportunity to provide accurate product tracking within the supply chain offers new possibilities to mobile supply chain management (m-SCM) applications (Kalakota et al. 2001).

E 1 - People tracking

People tracking: E.g. for children or elderly people. Child locator services allow the parents to locate their children via a secured web-site. The child therefore wears a special GPS watch.

GPS Locator for Children (Wherify Wireless)

E 2 - Integration of LBS for field support in CRM

Integration of LBS for field support in CRM: Location-based services for supporting field technicians and service order managers in customer relationship management solutions. Customer relationship management systems may be improved integrating location-based services in enterprise applications, including the Web environment.

E 3 - Monitoring services for fleets of vehicles or individuals

Monitoring services for fleets of vehicles or individuals: Monitoring mainly is used for businesses (e.g. shipping companies), or public services (e.g. police, fire patrol or ambulances). Examples are to operate fleet management applications, and track the location of external resources to optimize and schedule their use and control or ensure their safety. Here, external resources include individuals, whether in vehicles or not (truck drivers, delivery personnel, maintenance technicians, security personnel, etc), and objects (cars, trucks, trailers, containers and other

such items). Tracking services can also serve as logbooks. This can be for tax reasons, for the charging of travel expenses, holiday documentation but also for insurance and discharge of an accusation (e.g. car speed in the case of an accident).

E 4 - Infrastructure or facility management

Infrastructure or facility management: More specialised systems which do not target on the mass market are LBS for infrastructure management. Examples could be the management of a big industrial facility with technical building management (electricity, water, etc.), door inspection, cleaning management. Other examples would be in the infrastructure or environmental management of whole towns or regions such as water, wastewater, gas or also contaminated land. The benefits of LBS in this case are the easiness to find the locations, to add all the changes to a central database and e.g. the direct download of more detailed plans or other information. This enables the mobile field technicians to have all information that could be needed at hand.

F - Billing Services

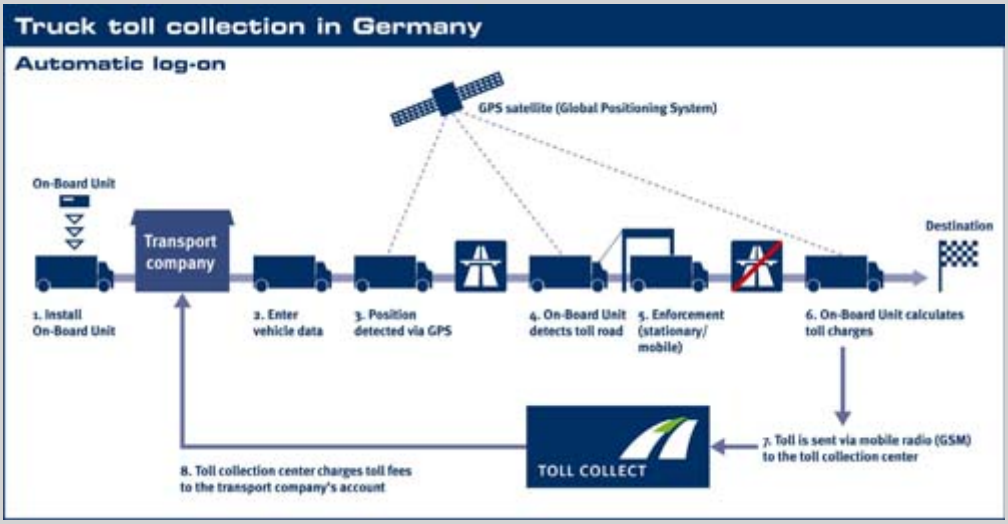
Location-sensitive billing refers to the ability of a mobile location service provider to dynamically charge users of a particular service depending on their location when using or accessing the service.

F 1 - Operator Services

Operator Services: User location information can be used to improve the way that services are implemented in areas such as network planning, quality of service, optimization of radio resources (handover and channel allocation) and pricing. Mobile network operators may price calls based on the knowledge of the location of the mobile phone when a call is made. Location-sensitive billing includes the ability to offer reduced call rates to subscribers that use their mobile phone when at their home, thereby allowing mobile operators to compete more effectively with their fixed telephony counterparts.

F 2 - Toll systems

Toll systems: A toll system that is capable of calculating and collecting road use charges based on the distance travelled. The automated tracking ensures that the collection of road tolls does not disrupt traffic flow.



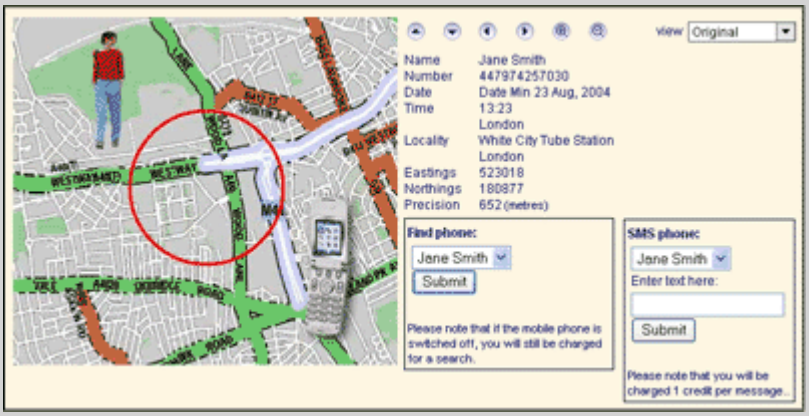
Truck toll collection in Germany (Toll Collect)

G - Games and Leisure

Tracking services can be equally applicable both to the consumer and the corporate markets. As far as similarly, tracking services can be effectively applied in corporate situations as well. One popular example refers to tracking vehicles so that companies know where their goods are at any time. Vehicle tracking can also be applied to locating and dispatching an ambulance that is nearest to a given call. A similar application allows companies to locate their field personnel (for example, salespeople and repair engineers) so that they are able, for example, to dispatch the nearest engineer and provide their customers with accurate personnel arrival times. Finally, the newfound opportunity to provide accurate product tracking within the supply chain offers new possibilities to mobile supply chain management (m-SCM) applications (Kalakota et al. 2001).

G 1 - Buddy finder / group management

Buddy finder / group management: These applications allow mobile users to locate friends, family, co-workers, or other members of a particular group that are within close range and thus, create virtual communities of people with similar interests.



Mobile Phone Tracking (Trace a Mobile.com)

G 2 - Geocaching

> **Geocaching:** Geocaching is an outdoor sport that involves the use of a Global Positioning System ("GPS") receiver to find a "geocache" (or "cache") placed anywhere in the world. A typical cache is a small, waterproof container containing a logbook and "treasure". Geocaching is a unique take on a traditional Easter-egg hunt in that it uses two recent technologies, the GPS and the Internet

G 3 - Mobile games

> **Mobile games:** Various mobile games already exist and the number is steadily growing. The variety of the games goes from simple mobile phone based games over handheld games with GPS to nearly augmented reality games with head-up displays and wearable computers. A nice example for an adaptation of an old computer game to the real world is PacManhattan. It is a live-action version of PacMan, played around Washington Square Park, in which people in Pac Man and ghost suits chase each other through the streets, seeking out power-pellets.

More examples can be found at **http://www.in-duce.net/archives/locationbased_mobile_phone_games.php**

H - Outlook - Augmented Reality

In the next decade, researchers plan to pull graphics out of the phone or computer display and integrate them into real-world environments. This new technology, called augmented reality, will further blur the line between what's real and what's computer-generated by enhancing what we see, hear, feel and smell. Other than in virtual environments, in augmented reality, the user can see the real world around him, with computer graphics superimposed or composed with the real world. Instead of replacing the real world it is supplemented. So called "see-through" devices, usually worn on the head, overlay graphics and text on the user's view of his or her surroundings.

Augmented Reality (How Stuff Works)

1.2.3. Summary

This section has provided some knowledge on user action and a lot of application examples. You should finally know the five types of **user actions**: locating, searching, navigating, identifying and checking and the corresponding questions like *"Where am I?"* or *"Where is...?"*.

Further you should be able to give examples on the four **information types** of static, topical, safety and personal information.
To **describe** a given LBS application you should remember that this can be done in terms of

- application area (e.g. navigation, emergency, information, etc.),
- positional accuracy needs,
- application environment (indoor/outdoor), and
- delivery type (push and pull services).

1.3. What's special about it?

Learning Objectives

- Through this unit you should be able to identify different types of context that are relevant to a user of mobile information service and list at least 5 of them
- You should be able to discuss at least 3 different ways a service can be made to respond context
- You should be able to describe at least 2 real world examples where context has been used
- You should be able to suggest relevant contexts and different methods for reacting to them when given an arbitrary information usage scenario

Introduction

Location-based services are different from more conventional paper and internet based media (guides, directories, maps etc.) because they are *aware of the context* [20] in which they are being used and can *adapt* [21] their contents and presentation accordingly. There are many different types of *context* [22], some of the most commonly considered are location, time and task. These relate to:

- where the user is,
- when they are using the service and,
- what they are using the service for.

However considerations such as *how old the user is*, *if it's raining* or *who the user is with* can be equally as important. Location-based services can respond to these types of context in different ways. They might *filter* information, for example by only retrieving restaurants within 10 minutes walk of a user's location, or they might present information in such a way that its relevance to a users context is enhanced, for example by using different map symbols for restaurants that are currently open compared to those that are closed.
In this unit we shall look at what context is and how it can be used to distinguish LBS application.

1.3.1. Context and Privacy

What is Context?
Context is any information that can be used to characterise the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application. This can include the user and applications themselves (Dey 2001). Various researchers have attempted to classify the different kinds of physical, social and cultural contexts that are relevant to a user when accessing an information service. For example, (Schilit et al. 1994); (Abowd et al. 1999); (Chen et al. 2000); (Dey 2001); (Mitchell 2002).
(2003) developed one such classification with specific reference to mobile services that are map-based. They define 9 types of context:

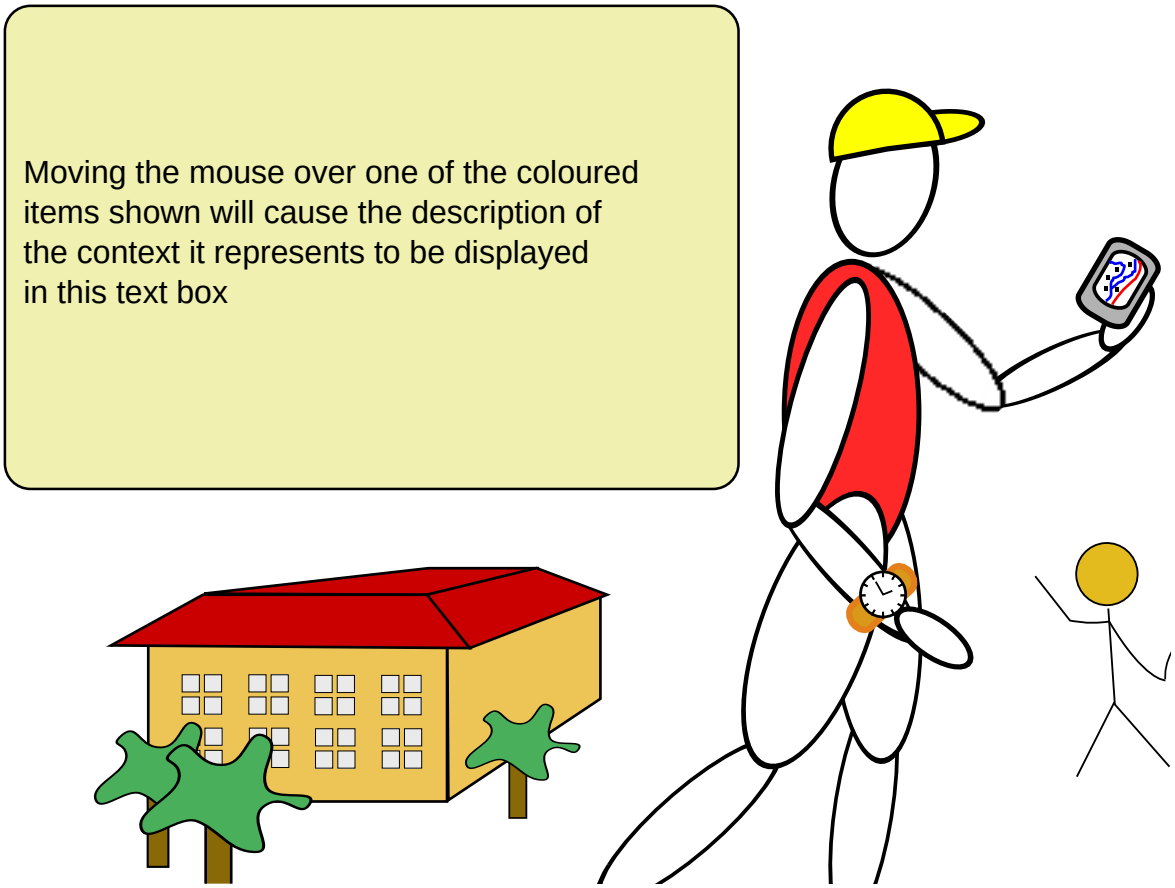
1. Mobile map user
2. Location
3. Time
4. Purpose of use
5. Social and cultural situation

[20] A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task.

[21] A system is adaptive if it is able to dynamically change its behaviour according to a user's needs and context

[22] Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves.

6. Physical Surroundings
7. Orientation
8. Navigation history
9. System Properties



Privacy

The sensing of context helps to deliver tailored information for a specific user, for instance to a visitor of a National Park as described by (2003). Such a park visitor could be interested in places where mushrooms did grow in the last years or where the next campfire location is. On the other hand context sensing raises many privacy concerns if people are tracked by their position or by analysing their preferences and action history. Such history analysis on one hand helps business applications to get a perfect customer model but can on the other hand raise user fears. Thus, context sensing is closely related to user security and privacy. To reduce user fears the user should be always informed about the information which is collected and the security of data transfer. Further, LBS user should have an option to decide if context based service features are turned on or off.

(2003) discuss in her **"Geoslavery"** article possible misuse of LBS techniques and describe possible threats to what Gorge (1949) calls **"Big brother is watching you!"** in his book "1984". We (the authors) like to recommend reading of the article to get a different view on what possibilities LBS technology offers.

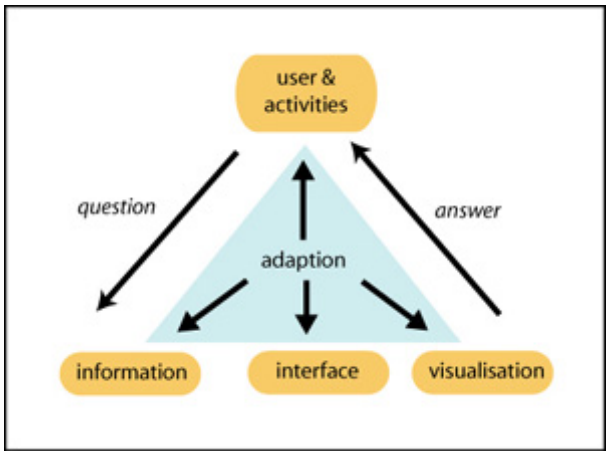
1.3.2. Adaption

How do services respond to context?

Systems that can dynamically change their behaviour because of context have been termed variously; reactive, responsive, situated, context-sensitive and environment directed (Abowd et al. 1999). However, the term *adaptive* has become the most commonly used in mobile cartography (Reichenbacher 2004).

Adaption can take place at four different levels (Reichenbacher 2003):

1. **Information level**: the content of the information is adapted. Examples include filtering information by proximity to a user or changing the level of detail of information according to tasks (Timpf et al. 2003).
2. **Technology level**: Information is encoded to suit different device characteristics (e.g. display size and resolution, network and positioning availability). For example using auditory driving instructions for users with mobile phones or maps for users with PDAs.
3. **User interface level**: the user interface is adapted. For example automatically panning and re-orientating a map as the user moves about.
4. **Presentation level**: the visualisation of the information is adapted. For example restaurants that are more relevant to a user's preferences in price and taste are shown with more crisp icons and those less relevant use more opaque ones.



Levels of adaption for mobile technologies after Reichenbacher (2004)

Exploring Adaption with an Interactive Tool

Use the 4 controls; locality slider, clock dial, activity selector, and user location to explore how the map adapts to the contexts of location, time and activity. To start set the clock time to 11 a.m., the distance slider to 1 km and activate all buttons.

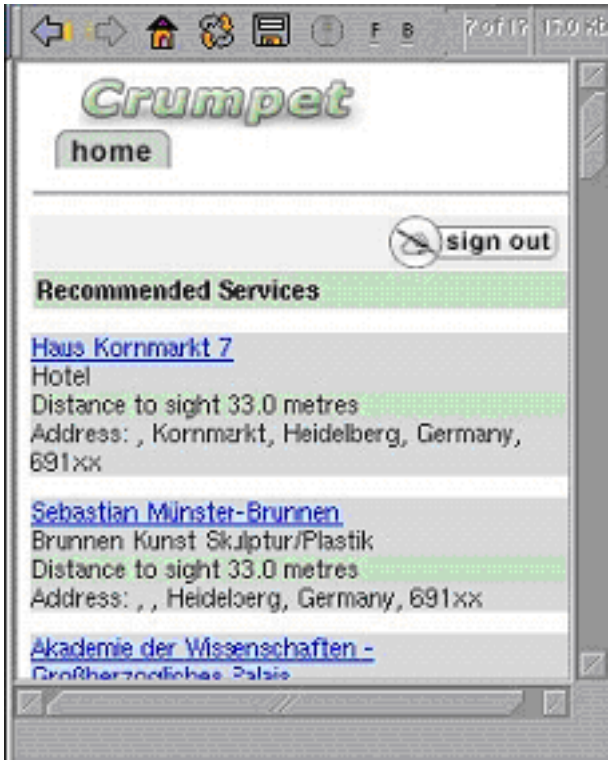
At which 2 levels does adaption occur?

- Information level - the information is filtered according to the activity and the proximity to the user
- Presentation level - the styling of the symbols changes according to the time and how much longer a facility is open for

1.3.3. Examples

A - Adaption to user preferences

Adaption has been applied in practise in a number of varied and novel ways. In the CRUMPET project (Schmidt-Belz et al. 2003) researchers looked at how tourists could benefit from the provision of sight-seeing information. They adapted the information content according to the context of the user`s personal preferences for different types of information and their current location.



Example search results from the CRUMPET project with respect to personal preferences (Schmidt-Belz et al. 2003)

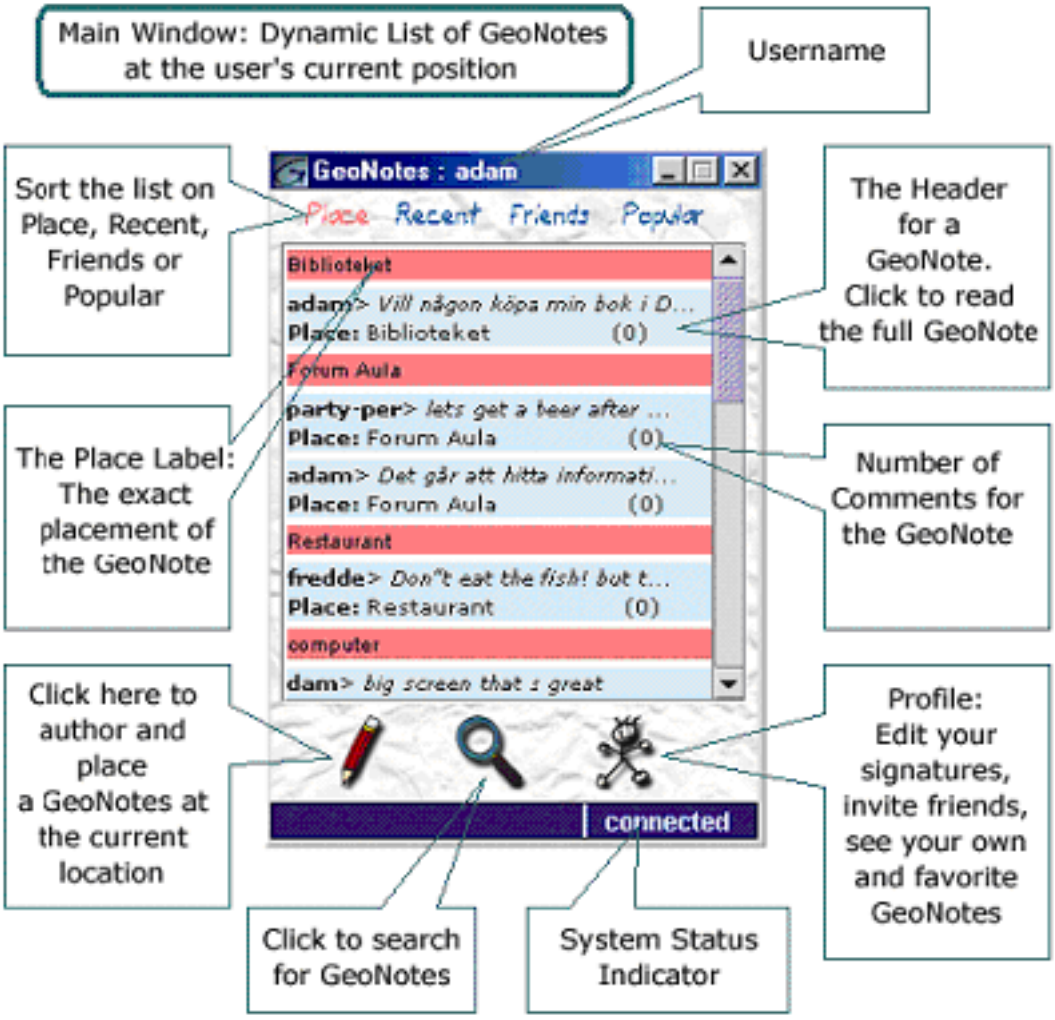
B - Adaption to seasons of a year and to user age

In the GiMoDig project (Nivala et al. 2003) researchers used the contexts of the user, the time of year and the purpose of use to adapt the content and presentation of maps. For example icon styles were varied according to the age of the user, and different recreational activities were shown at different times of the year.

Maps adapted to for the GiMoDig project (Nivala et al. 2004)

C - Adaption to location and social context

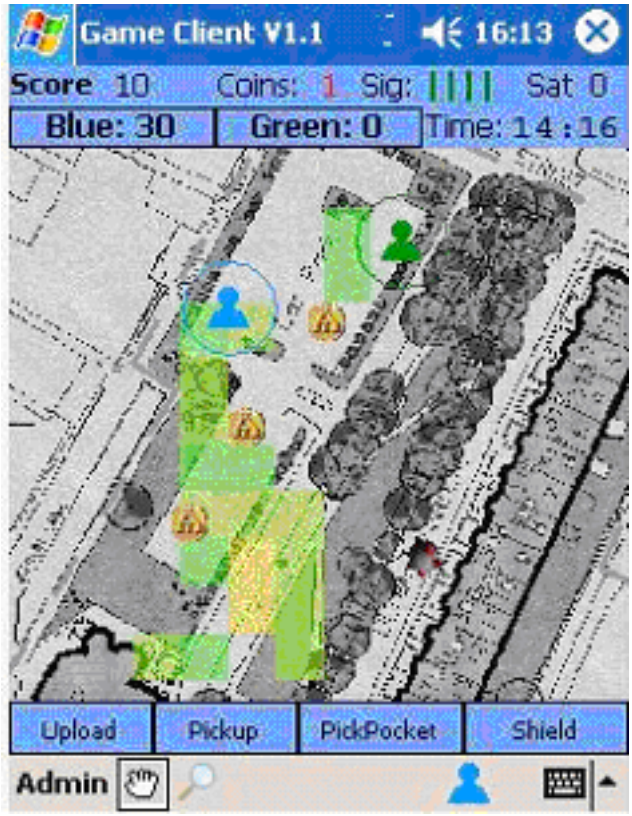
(2002) and (2002) both looked at how location and social context could be used to help guide new students on a university campus. Their systems adapted the information contents according to location, time of day and social relationship between students and student groups. The contents consisted of virtual notes left by students at locations anywhere in the university, which would pass on information, experiences and preferences about what goes on where and when at that note's location.



A virtual note (Persson et al. 2002)

D - Adaption to system context

(2004) used the system context to adapt the content and presentation of information. They designed a cat-and-mouse type multiplayer game where players could use dead spots in the network and GPS coverage to hide from other players.



A seamful game (Chalmers et al. 2004)

1.3.4. Self Assessment

Scenarios for context-awareness

Describe relevant contexts and how a service might be adapted to them in the following scenarios.

- Navigation - You want to create an information service to assist people navigating. Describe the kinds of context that affect a person trying to get about, how they affect the planning and undertaking of a journey, how they might change during travel. Suggest different ways to adapt a service to consider these contexts so that the users can get efficiently and safely to their destination.
- Nature lover - You want to provide an information system to visitors of a nature reserve for birds. List the different types of context that might effect a bird-watcher in such an area and suggest how the service might be adapted to help them observing and identifying different species of birds
- Student - you want to provide an informaiton service to help students with their studies, for example finding books and finding a place to sit at one of the university libraries. List the different types of context that might be relevant to a student and how the contexts change during the day. Suggest ways a system could be adapted to consider these.

1.3.5. Summary

This unit tried to show you that **context awareness** makes LBS applications very special compared to other information technologies. With the animation you could interactively explore which different types of context exists if moving the mouse over the watch (time), the people in the background (social context), the arrow on the ground indicating the walking direction (orientation) or the footprints as a metaphor for the user action history.

The second section of the unit shows you how context can be used by **adaptation**. Apart from the examples you could play with a interactive tools and explore adaption by moving the pointer of the clock or the distance slider. You should finally know that adaption can take place on four levels: information, technology, user interface and the kind of presentation.

1.4. How does it work?

Learning Objectives

- You should be able to list 3 device types.
- You should be able to draw a sketch with the basic information on wireless network types.
- Given a diagram of the LBS components you will be able to explain how a service request - answer process is performed.

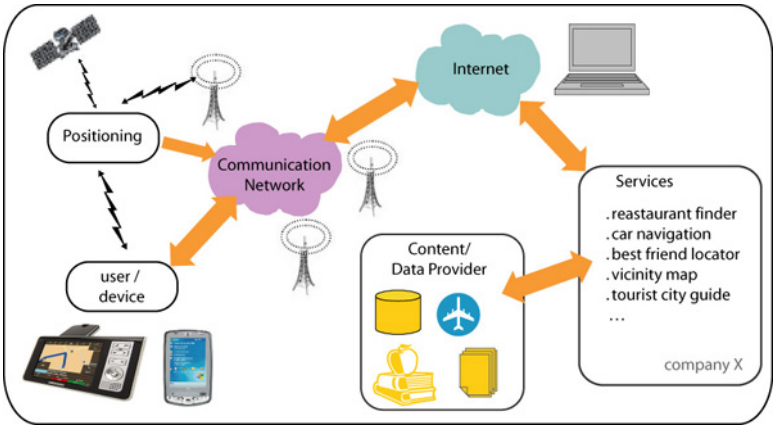
The basic components necessary to use and provide LBS services have been listed in the section **What are LBS?**. These technical basic components are: devices, communication network, positioning technologies, Types of Services and Data. In this section we will give some basic information on these components, with exception of LBS service types.

1.4.1. Architecture

Considering the example of searching a Chinese restaurant the information chain from a service request to the answer will be described in the following and is illustrated as animation below. The information the user want is a route to a Chinese restaurant near by. Therefore the user expresses his need by selecting the appropriate function on his mobile device: e.g. menu: position information => searches => restaurants => Chinese restaurant.

1. Now if the function has been activated, the actual position of mobile device is obtained from the Positioning Service. This can be done either by the device it self using GPS or a network positioning service. Afterwards the mobile client sends the information request, which contains the objective to search for and the position via the communication network to a so called gateway.
2. The gateway has the task to exchange messages among mobile communication network and the internet. Therefore he knows web addresses from several application servers and routes the request to such a specific server. The gateway will store also information about the mobile device which has asked for the information.
3. The application server reads the request and activates the appropriate service - in our case a spatial search service.
4. Now, the service analyses again the message and decides which additional information apart from the search criteria (restaurant + Chinese) and user position is needed to answer on the request. In our case the service will find that he needs information on restaurants from the yellow pages of a specific region and will therefore ask for a data provider for such data.
5. Further the service will find that information on roads and ways is needed to check if the restaurant is reachable (e.g. sometimes a restaurant on the other river side might not be reachable since no bridge is near by).
6. Having now all the Information the service will do a spatial buffer and a routing query (like we know from GIS) to get some Chinese restaurants. After calculating a list of close by restaurants the result is sent back to the user via internet, gateway and mobile network.

The restaurants will now be presented to the user either as a text list (ordered by distance) or drawn in a map. Afterwards the user could ask for more information on the restaurants (e.g. the menu and prices), which activates a different kind of services. Finally if he has chosen a specific restaurant he can ask for a route to that restaurant.



LBS components and information flow.

1.4.2. Devices

The applications presented **How is it useful?** emphasise that very different types of LBS applications exists and show further that LBS users can be persons or machines. In dependence on *skills of a user to handle electronic devices*, the *storage capabilities* of a device, *the user need* of applying several services or fulfilling only a specific task a broad range of devices exists. Based on the latter device property LBS devices can be distinguished into **single purpose** and **multi purpose** devices.

A **single purpose device** is for instance a car navigation box, a toll box or a emergency remote for old or handicapped people. As well part of that category are devices which call service engineers or rescue teams. But also more advanced systems like augmented reality systems - which might be used by a state inspector for bridges and other buildings - belong to it.

Multi purpose devices will be used by a broad number of people and will be part of our everyday life. Such devices can be mobile phones, smart phones, Personal digital Assistants (PDA's) but also Laptops and Tablet PC's.

Different LBS devices.

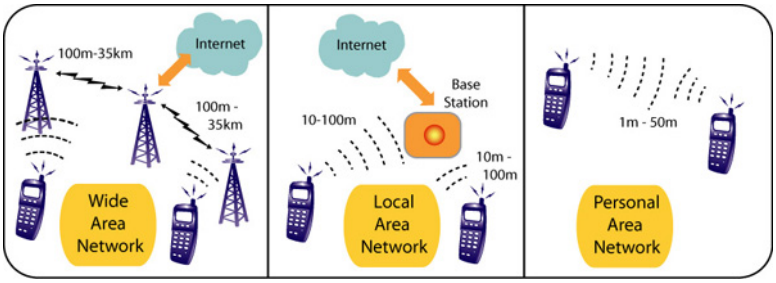
Limits

If we especially look on the multi purpose devices like mobile phones and PDA's one has also to speak about the limits of such devices. Most of them have small **computing and memory resources** which restricts spatial search calculations, routing operations and the creation of a user specific "mobile" map. Therefore such operations are done on a service server which sends the results to the user. Further limits are given by **battery power, small displays and weather influences**

on usability (sun makes things showed on a display hardly visible). Also in terms of sending and receiving data there is still a lack on broadband **access to communication networks**. A non technical challenge for such small devices is for example the design of user interface to support user interaction with respect to hardware and software.
Some of the technical problems like computing resources are more or less contemporary and will probably solved within the next years. Further points on limits of mobile devices with a focus on mobile cartographic applications will be discussed in Lesson 2 on **LBS Techniques**.

1.4.3. Wireless Networks

As already seen in the previous section the wireless communication networks transfer user data and service request messages from the mobile terminal to the service provider and further the requested information back to the user. A possible second task is to use the mobile network to obtain the user position. In general a classification of wireless networks with respect to the *covered area* is preferred. A useful classification is done into **Wireless Wide Area Networks (WWAN)** - e.g. GSM and UMTS, **Wireless Local Area Networks (WLAN)** and **Wireless Personal Area Networks (WPAN)** - e.g. Bluetooth.
Common to WWAN and WLAN is the principle of a mobile terminal and a base transceiver station. For WWAN a structured network (backbone) of such base stations is necessary to cover a country. Since every base station covers a specific area one does call such network types also *cellular networks*. Usually the network cells for WWAN overlap only by small portions.



Different wireless network types. W-WAN: Wireless Wide Area Network, W-LAN: Wireless Local Area Network and W-PAN: Wireless Personal Area Network

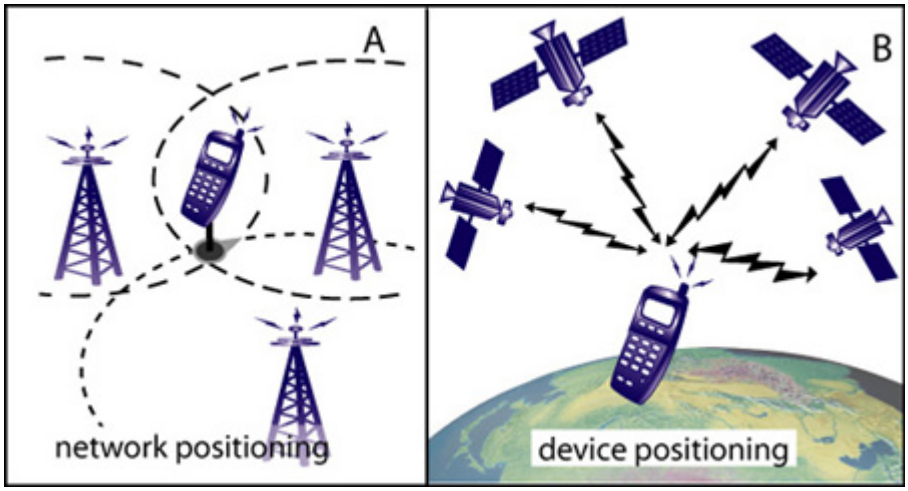
Since WLAN and WPAN cover small areas, (2004) emphasize that these network types are suited for information services with high granularity like consumer portal services (e.g. navigation in a shopping mall or museum). In the opposite WWANs are likely to support large scale services like fleet management, safety and telematics services, which may cover regions of or a whole country. They are therefore useful only for a smaller set of information services.
More introductory information on wireless networks are given in the unit **"Networks & Positioning"** of **LBS Techniques** and can be found in (2004).

1.4.4. Positioning

In the previous section, which described the general information workflow, a **positioning service** has been introduced to obtain the user location. We will now give a short introduction to positioning methods. A more detailed discussion is done in the Unit **Networks & Positioning** of the Lesson **Techniques for LBS Cartography**.
If we do not consider the manual input of the position as a location method a general classification of positioning methods can be done into two groups: The first group is called **network-based positioning**. Here, a tracking and evaluation of the user location is done by using the base station network (see image A). Using this technique either the mobile device is sending a signal or the device is "sensed" by the network. The position is calculated by the control stations of the network.

The second positioning group is called **terminal-based positioning**. In this case the location is calculated by the user device itself from signals received from base stations. A well know example for a terminal-based system is the location determination by use of the Global Positioning System (GPS), and also Galileo in several years. The base stations for the GPS system are the GPS-satellites (see image B in the Figure). Finally a third group of positioning techniques emerges from combination of network and terminal positioning techniques.
The basic principle for the calculation of the user position, valid for all groups, is:

1. Base Stations have a known position.
2. Information from a signal is transformed into distances (*N.B.*: this is not valid for Angle Of Arrival (AOA) technique).
3. Using the obtained distances (device - base station *x*) as circle radius around the base station. Obtaining the position from the arc intersection (see image A)

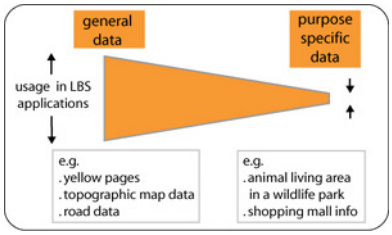


Types of positioning and basic principle.

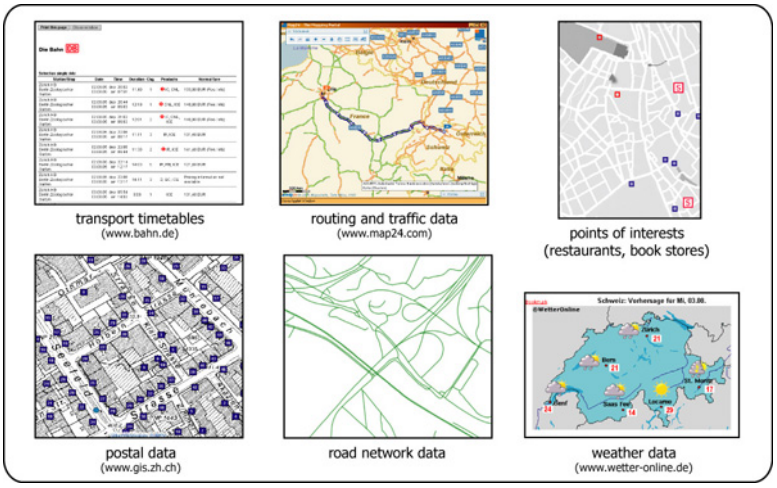
The currently two most common position technologies are the already mentioned GPS and the position evaluation using the Cell-ID from the nearest base transceiver station, a network method. Whereas GPS delivers a very accurate position (accuracy up to 5m) does the Cell-ID deliver a very coarse position (accuracy between 100m to 30 km). Especially GPS is (currently) an outdoor positioning method. To obtain indoor positions with high accuracy, as needed for instance in museums or shopping malls, localisation methods based on WLAN, Bluetooth or infrared technologies should be applied. In general it is important to note that the position technology and its accuracy influences the application of different location based services (see also application examples in **Unit 2**).

1.4.5. Content

The needed data can be very different and depends on the kind of services offered, that is on its global or specialized application character.



Purpose Specific LBS Applications are for instance services which help localizing handicapped people or services provided by a national park. For the first example, monitoring handicap people, only the position and mapping data is necessary, to show the patient position on map) the patient. Further the monitoring service could introduce (own) risk zones where an alert is activated if the patient enters the zone. For the second example, a national park LBS, again some background data for positioning information is useful. Such mapping data could be obtained from the country **mapping agencies**. Other national park services which answer questions like: *What kind of tree is it?* and *Where to find an owl?* will probably be in the park **own information data bases**. Additional information could be provided by an electronic **encyclopaedia system** of a publishing company.
General LBS Applications are offered by telecommunication providers like NTT DoCoMo, Telecom, Vodaphone, AT & T or specialized companies, which provide their services to user of different telecom networks. Examples of these general data are shown in the figure below.



Different data from different data providers for LBSs.

1.4.6. Summary

This unit presented on one hand the processing chain of a service request and on the other hand some basic knowledge on the five components of LBS. Considering the different components you should know

- that we can distinguish between single and multi purpose devices and further be able to list some device types, e.g. mobile, toll box, PDA, navigation unit;
- that networks can be classified with respect to the area of coverage and that we distinguish between WWAN, WLAN and WPAN;
- that the location of a mobile user can be determined using either network-based positioning or terminal based positioning methods. Further you should remember that the basic principle of position calculation is based on the intersection of distance-circles around base station;
- that data for LBS applications may be classified into purpose specific and general data. And you should be able to list some data type - e.g. yellow pages, topographic data, road data or shopping mall information.

1.5. Summary

Location Based Services will become more and more part of our everyday life. First services are already provided for mobile phone users like friend finders, weather information or city event boards. Other location services like road tolling for trucks or fleet management are also already operational LBS business applications. In this lesson we defined first what Location Services are and presented afterwards some fundamental characteristics of such services:

- We saw that the LBS architecture consists of **five basic components**: Mobile Devices, Positioning, Communication Network, Service Providers and Content Providers. These components have been shortly discussed in the last subsection of the lesson. Further we gave an example how these components act together in the processing chain of a service request sent by a user.
- In the second section we presented **user actions** and questions from which the types of services (operations), needed by users, emerge. Five types of actions have been identified: locating, searching, navigating, identifying and checking.
- **Context awareness** has been emphasised as a major feature of LBS technology. Therefore context has been defined and 9 types have been listed and visualized (e.g. location, time, social situation, system, etc.).
- Using context in an LBS application has been introduced as **adaption**. Four levels of adaption have been identified (information, technology, user interface and presentation) and effects could be discovered in an interactive tool.
- Finally a long list with LBS application examples has been given and four properties to **characterise** an application are presented: the application area (e.g. navigation, emergency, information, etc.), positional accuracy needs, application environment (indoor/outdoor), and delivery type (push and pull services).

Since this lesson does present only the basics on LBS the further lesson will give some closer insight into the characteristic, partially with a specific focus on map presentations of results received from a Location Service. Some of the LBS Components (Networks, Devices and Positioning) introduced here will be discussed in the Lesson **Techniques for LBS Cartography** in more detail. User actions and goals as well as context will be issues of the Lesson **Designing Maps for LBS**. But context will also play a role in a further lesson on **Solutions for small screen map design**.

1.6. Recommended Reading

- **Dobson, J. E., and Fisher, P. F.**, 2003. Geoslavery. *IEEE Technology and Society Magazine*, 47-52.
- **Reichenbacher, T.**, 2004. *Mobile Cartography - Adaptive Visualisation of Geographic Information on Mobile Devices*. (PhD). Technical University, Munich.
  Download: http://tumb1.biblio.tu-muenchen.de/publ/diss/bv/2004/reichenbacher.pdf

1.7. Glossary

adaption:

A system is adaptive if it is able to dynamically change its behaviour according to a user's needs and *context*

Communication Network:

These LBS component transfers the user data and service request from the mobile terminal to the service provider and then the requested information back to the user.

context:

Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves. (Abowd et al. 1999)

context aware:

A system is context-aware if it uses *context* to provide relevant information and/or services to the user, where relevancy depends on the user's task. (Abowd et al. 1999)

Data and Content Provider:

Service providers will usually not store and maintain all the information which can be requested by users. Therefore geographic base data and location information data will be usually requested from the maintaining authority (e.g. mapping agencies) or business and industry partners (e.g. yellow pages, traffic companies)

Information:

What is needed to answer a user question and how is it done? A model of information retrieval is needed to answer the user questions. Such an information process model contains a model of possible questions, defines Queries of geographic base data and location information data, and specifies possible answers (see animation below).

LBS Definition 1:

LBS's are information services accessible with mobile devices through the mobile network and utilizing the ability to make use of the location of the mobile device. (Virrantaus et al. 2001)

LBS Definition 2:

A wireless-IP service that uses geographic information to serve a mobile user. Any application service that exploits the position of a mobile terminal. (Open Geospatial Consortium 2005)

Mobile Activities:

What Questions and Problems have users? Such questions do emerge from the user actions: locating, navigating, searching, identifying, event check. A further question with respect to actions is the (spatial) scope of activities. According to (2004) we can distinguish three types of spatial scope:

1. Macro scale: Do I need an overview?
2. Meso scale: What is reachable for me?
3. Micro scale: Where am I?

Mobile Devices:

A tool for the user to request the needed information. The results can be given by speech, using pictures, text and so on. Possible devices are PDA's, Mobile Phones, Laptops, ... but the device can also be a navigation unit of car or a toll box for road pricing in a truck.

Mobile User:

Who or what is mobile? The mobile object can be a person or a device like a car navigation system. (see further **How is it useful?** and (2004))

Positioning Component:

For the request of LBS the user position has to be determined. Here one distinguishes between tracking (a network determines your position) and positioning (position self evaluation). Usually the user position is obtained either by using the mobile communication network or by using the Global Positioning System (GPS). Further possibilities

to determine the position are local networks like Bluetooth or WLAN, active badges or radio beacons. The latter positioning methods can especially used for indoor navigation like in a museum. If the position is not determined automatically it can be also specified manually by the user.

Pull Service:

The user asks actively for information or assistance.

Push Service:

That the information is delivered without asking to the LBS user.

Search and Spatial Analysis:

Which methods and algorithms are suitable for real-time information query in the Internet and spatial data analysis? Further question are: ”How to integrate data and information of different scale, quality, data types, prices?" "How is the data availability and actuality?"

Service Accuracy:

The accuracy of the positioning method ...

Service and Application Provider:

The service provider offers a number of different services to the user and is responsible for the service request processing. Such services can be the calculation of the position in a more global context, to find a route, to search the yellow pages with respect to position, find information on a specific object of user interest (e.g. a bird in wild life park) and so forth.

Service Delivery:

The way how information from a LBS is retrieved or delivered to the user.

Service Environment:

The environment in which a LBS is usually used

Technology:

How are service requests and data transferred between user and service provider? Where are the data stored? Which services are provided? Which positioning technology is used? ...

User Interface:

Is a person using a PDA or mobile phone or something else? How can the user or (navigation) system formulate his needs and can make them more concrete after obtaining an overview?

Visualisation:

How is the information, returned from LBS, communicated to the user? Speech, text, pictures, pictograms, maps, lists,..

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