Techniques for LBS Cartography

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1. Techniques for LBS Cartography

Learning Objectives

You will be able to ...

- describe the basic functionalities and limitations of mobile LBS enabled devices.
- explain what positioning methods are available for LBS and how the LBS devices can communicate via wireless networks.
- relate from different data formats to the role of map response in terms of usability and map response.
- describe the main components of a LBS System Architecture and how they interrelate.

Introduction

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For providing and using LBS four main components are needed and have to be combined. A LBS is usually accessed via a mobile electronic device. This device, or mobile computer terminal, should be the only point of contact between user and LBS. All other components, especially the technical ones like positioning and data communication, are usually yielded and should work without knowledge of the user. If the user wants to use a location based service different infrastructural elements are necessary. In the figure the four basic components Mobile Devices, Positioning, Communication Networks and Service & Content Providers.
This lesson shows the technical aspects of the LBS components mobile devices in the first unit, of positioning and communication networks in the second and of service & content providers in the two remaining units.

1.1. LBS Devices & Displays

Learning Objectives

You will be able to ...

- list the major groups of mobile devices with their advantages and limitations.
- describe the limitations of small mobile device screens.

The mobile device is the point of contact between the user and the LBS. There is a big variety of different devices which could be used for different LBS. The design of a LBS depends also on the type of devices it will be used with.

On the one hand there are everyday devices like mobile phones or standard *PDAs* [1]. As many people already have such devices, they arevery apt for mass market LBS. However the technical capabilities of these devices are limited.

On the other hand there are specialised multi purpose devices like laptops or tablet PCs which are more likely to be used for professional purposes like LBS for sales representatives or facility management.

This unit gives an overview about common devices and their limitations especially in terms of the graphical capabilities.

Typical LBS devices: Nokia mobile phone with Route66 routing software and Hewlett Packard PDA with the WebPark Information System (courtesy of Swiss National Park).

1.1.1. Mobile Devices

LBS devices can be very different but do mostly have some common characteristics like the limited screen size, processing power and memory. Based on the latter device property LBS devices can be distinguished into single purpose and multi purpose devices (see **LBSBasics**).

The following examples show some common device types which are used for LBS. As the development in the domain of electronic companions of any kind is going on very fast, this listing does not claim to be complete or absolutely up to date. The devices which are shown here are the typical devices of the year 2005.

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[1] Personal Digital Assistant, also known as Handheld Computer, Personal Information Manager (PIM),or Pocket Computer. A small, handheld device capable of storing appointments, adresses, documents, messages. PDAs can also function as a cellular phone, e-mail device, Web browser and personal organizer. Unlike portable computers, most PDAs began as pen-based devices that used a stylus rather than a keyboard for input. Many PDAs subsequently incorporate handwriting recognition features.

Multi purpose devices are used by a broad number of people as part of everyday life. Such devices can be mobile phones, smart phones, Personal digital Assistants (PDAs) but also Laptops and Tablet PCs.

 	The **mobile phone** is the typical every day companion. LBS for mobile phones are very promising for the service providers, because of the high number of potential users. With the appearance of more and more java enabled mobile phones there is also the possibility to add additional software applications like LBS to a standard mobile phone. The biggest drawback is still the lack of accurate **positioning** methods. But here is still much development going on. Typical for most java enabled phones is a screen resolution between 160x208 and 240x320 and the size is usually between 25mm (1”) and 60mm (2.3”). The control of the phone’s functionalities is usually done via the standard phone keys, some special keys and often some sort of a tiny joystick. Usually the processing power of such mobile phones is not very high and the inbuilt memory is limited to some megabytes. However most devices can be extended by an additional memory card up to 512 megabytes or even 1 gigabyte and connected to external devices such as GPS receivers via *Bluetooth* [2]. The power consumption of mobile phones varies very much but usually a fully charged battery lasts for a couple of days. Examples for java enabled devices are the Motorola RAZR V3, Nokia 6600, Samsung D500, Siemens M65, or SonyEricsson K500i.
 	The second family of devices for LBS are the so called **smart phones** and **PDAs**. Such Personal Digital Assistants were originally intended as electronic calendars and address-books but were soon extended with more and more functionalities. Generally there are three main categories of PDAs. First there are the normal PDAs without or only with limited range wireless connectivity. Second are the smart phones which have long range wireless connectivity like GSM/GPRS or UMTS. And finally there are devices which also include a GPS for an accurate positioning. Typical for most smart phones and PDAs is a screen resolution between 208x320 and 480x640. The screen size varies between 50mm (2”) and 125mm (5”). PDAs have usually between 32 and 128 megabytes of inbuilt memory and can be extended by additional memory cards to some gigabytes. The control of the PDA’s functionalities is usually done either with a tiny keyboard and some sort of a tiny joystick ore more common with PDAs with a stylus on the screen (with handwriting recognition). The power consumption is one of the biggest problems with PDAs. While normal standard PDAs which are only used as calendar and address-books can be used continuously for more than 10 hours, more advanced devices with wireless connection or GPS achieve only 4 hours of continuous usage. Like mobile phones also many PDAs allow the execution of Java applications. But more sophisticated applications have to be developped especially for the operating system of the PDA.

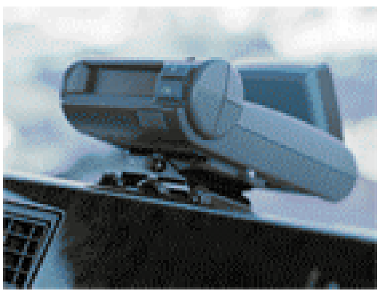
[2] A wireless technology developed by Ericsson, Intel, Nokia and Toshiba that specifies how mobile phones, computers and PDAs interconnect with each other, with computers, and with office or home phones. The technology enables data connections between electronic devices in the 2.4 GHz range. Bluetooth would replace cable or infrared connections for such devices

 	Also **Laptops** or other **mobile computers** can be used as devices for LBS. The big advantage of a laptop is the screen size and resolution. But the size and the weight of the laptop plus the limited runtime from usually 2-4 hours are not very appropriate for having the device as an all-day companion. Typical screen resolutions 1024x768 or more and the screen size goes from 250mm (10”) up to more than 400mm (17”). Memory is due to a hard disk absolutely sufficient for all LBS applications and extensibility with external devices can be done by wired or wireless connections such as *Bluetooth*. A special type of a laptop the so called Tablet PC can be interesting for LBS in a professional context, such as for sales representatives, facility maintenance or surveyors. These mobile computers are comparable in the size and weight to a small Laptop but can be controlled with a stylus directly on the screen. Thus no mouse or keyboard is needed and it can be used while standing or walking.
	**Wearable Computers** are still very uncommon and have a futuristic effect. But in a professional environment they are already in use for so called *augmented reality* [3] systems. For example state inspectors for infrastructure installations, buildings or industrial facilities get up-to-date information in combination with their current position and can access e.g. construction plans for getting more support. A wearable computer is a small portable computer that is designed to be worn on the body during use. In this wearable computers differ from PDAs, which are designed for hand-held use, although the distinction can sometimes be a blurry one. Wearable computers are usually either integrated into the user's clothing or can be attached to the body through some other means, like a wristband. Wearable computers can have a small display which attached e.g. to the users arm. But mostly wearable computers are used with head mount displays. Theses head mount displays are either mounted on a helmet or worn like eye glasses. The image is projected into the glasses in a way that the user has the perception that the images are coming from a greater distance. In this way the reality and the computer images can be mixed in order to show augmented information. The displays have usually a resolution of 640x480 pixels or more. As the image appears at some distance the virtual size of the display can be several meters.

Single purpose device are especially designed for the type of LBS and for the environment they are used in. Thus usually they offer only the functionalities that are designed for and are unlike mobile phones or PDAs not extendable. Examples are a car navigation device, a route tolling box or an emergency remote for old or handicapped people. As well part of

[3] is a field of computer research which deals with the combination of real world and computer generated data. At present, most AR research is concerned with the use of live video imagery which is digitally processed and "augmented" by the addition of computer generated graphics. Advanced research includes the use of motion tracking data, fiducial marker recognition using machine vision, and the construction of controlled environments containing any number of sensors and actuators.

that class are devices which call service engineers or rescue teams. These devices have often proprietary software and are difficult to extend with additional applications. Thus these devices are listed only for completeness. However the development of LBS mainly focuses on multipurpose devices.

	As seen above is GPS getting more and more integrated into multi purpose devices like PDAs or mobile phones. But also the specialised **standalone GPS** devices offer some LBS through their integrated maps with roads and points of interest. Thus e.g. a search for the nearest restaurant can be performed on such devices. The map display on these devices ranges from monochrome maps up to full colour maps. Resolution and screen size are comparable to PDAs. The operating systems and software on the standalone GPS devices are mostly proprietary. Almost every device maker uses its own system with own maps and own LBS functionalities. Thus adding new LBS functionalities is usually not possible for others than the device's producers. Examples are devices with integrated maps from Garmin, Magellan or Lowrance.
	Also **standalone navigation systems** do offer some LBS functionalities through their integrated road and points of interest maps. As for the standalone GPS devices also the standalone navigation systems mostly use proprietary operating systems and are therefore not open for individual applications like other LBS. Examples are portable and car mounted devices from TomTom, Garmin, Magellan or Navman.
	**On-Board-Units** (OBU) for cars and trucks belong to telematics. They offer very specialised services like road tolling, car assistance or also traffic management. However these devices are even more specialised for their purpose than the standalone navigation systems. Thus the displays are often monochrome or even only character based which makes the use for an LBS with maps impossible.
	As well as the OBUs also the **tracking and rescue devices** are much specialised for their type of use. Tracking a person or a device is usually done by some operator. Thus the person being tracked carries only a sender which transmits the actual person while the actual position and other information is requested by a operator on his computer. Thus the tracking devices can be very small and don't even need a display. Examples are watches with integrated GPS for locating children or rescue buoys for transmitting the position of a sailor in distress.

1.1.2. Displaying Content

Coping with Small Displays

Handheld devices are characterized primarily by a limited display size. If we look at a standard web page which is optimised for normal desktop computers like the Yahoo News page. Graphics, in the form of logos, icons, frames, and images, both increase page load times and unnecessarily occupy this limited space. Thus forcing the relevant information to the outskirts of the display area. In the following two screenshots the differences between device-optimized and non-optimized presentation of content can be seen:

non-optimized device content

optimized device content

Maps on Small Displays

The web page example above applies also for displaying maps on small displays. In the following example you can test how much content can be displayed at once on a PDA screen. Just change symbol numbers and symbol sizes by dragging the green buttons. Evaluate how big a symbol has to be for being recognisable and then how many symbols can be shown on a map in order to keep the map readable. Keep in mind that also the background map, containing roads and buildings has to be readable.

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1.1.3. Display Facts

Display Technologies

Colour *LCD* [4] (Liquid Cristal Display) displays have somewhat become standard in mobile phones and PDAs. But the different LCDs differ very much in colours, size and resolution. The display contrast and brightness as well as the size and the sharpness depend on the technology used for the display. There are two basic technologies used today in colour LCDs: active-matrix, commonly called *TFT* [5], and passive-matrix, commonly called *STN* [6]. Comparing the two technologies, TFT has a higher contrast (it therefore seems brighter and easier to see), has more saturated colors, can be viewed at wider angles, and is generally more expensive than STN. LCD manufacturers are in general moving away from STN and towards TFT. But TFT LCDs are usually consuming more energy which is influencing the device runtime.
The display brightness and contrast can also be influenced by the display reflectivity in combination with sunlight. When using such a device outdoors colours and contours can be sometimes very hard to see because of bright sunlight and/or reflections in the display.

Map in a PDA display at normal light, outdoors and with reflections

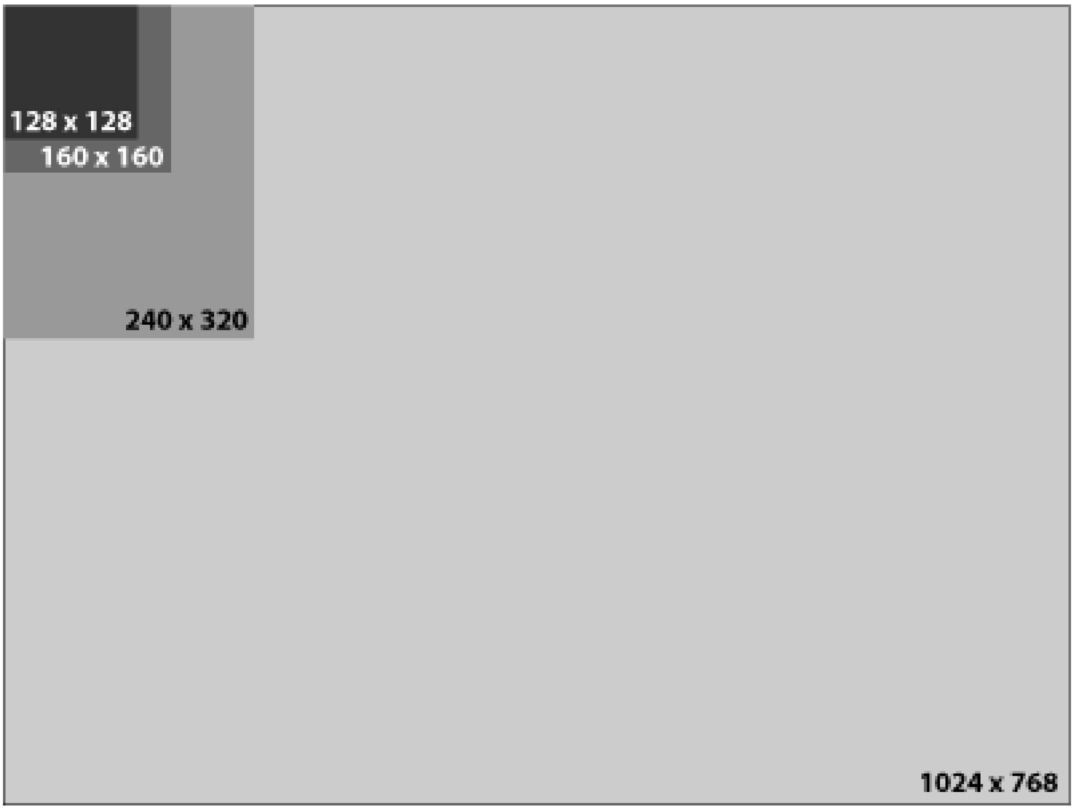
Display Resolution and Size

In the image below you see some common display resolutions of LCD displays. The largest one with 1024 x 768 pixels is the resolution of a standard notebook or home computer. Thus a common PDA display with 240 x 320 pixels can show only approx 1/8 of the amount of information a normal computer screen can show.

[4] Liquid Crystal Display, LCDs utilize two sheets of polarizing material with a liquid crystal solution between them. An electric current passed through the liquid, causes the crystals to align so that light cannot pass through them. Each crystal, therefore, is like a shutter, either allowing light to pass through or blocking the light.

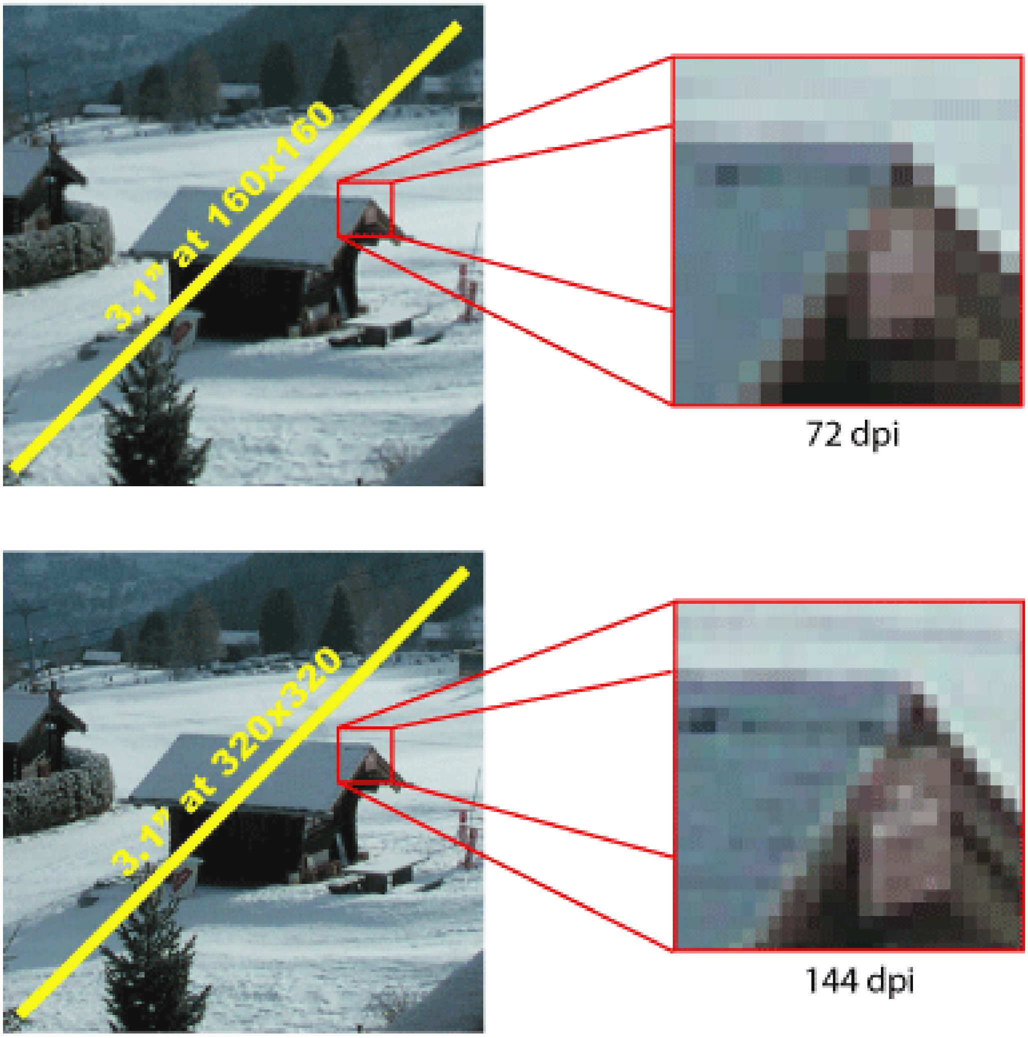
[5] Thin-Film Transistor, technology for active-matrix screens in laptops, PDAs and cell phones. TFTs are composed of a matrix of pixels. The thin-film transistors act as switches for turning the pixels of the screen individually on and off.

[6] Super Twisted Nematic. Viewing range 180°. Most common LCD type. The wide viewing range and high contrast makes it a good choice for many applications. Commonly available as very dark blue on yellow/green or grey background. As it is made in volume, cost is comparable to lesser types in all except highest volume.



Different Screen Size Proportions

Resolution and size are closely related -- in general, the more pixels (dots) there are in an LCD, the larger is it's resolution. Actually the number of dots per inch (dpi) in LCDs shipping in products today ranges from a low of 70 to more than 200. Most current LCDs fall in the range of 90 to 150 dpi. Pixels are dots of RGB-colored light that make up all computer images. The more pixels that can be displayed on a screen, the greater detail and the more information that can be displayed on the screen at one time and the image looks more sharp. The resolution is described by the number of columns and rows of pixels that can be displayed. For example, a display capable of displaying 128 x 160 is able to display 128 columns by 160 rows of information.



Relation between display size and resolution. Typical Palm display with 160x160 () or 320x320 pixels.

The two examples above show the typical screen size of a Palm PDA with two different resolutions. The inexpensive Palm PDAs are only equipped with a 160x160 pixel display while the better screens have a 320x320 pixel display. The size of the displays however is 3.1" for both devices. Thus the better display can show more information at the same size an is much sharper.
In the following table typical display resolutions and sizes for mobile devices like phones, PDAs and notebooks are listed:

LCD Resolution	Size Range	Application
128 x 128	1" (128dpi)	phones
176 x 220	1.8" (156dpi)	phones
240 x 320	1.8" (210dpi) - 4.2" (90dpi)	phones
160 x 160	3.1" (72dpi)	Palm PDAs
320 x 320	3.1" (145dpi)	Palm PDAs
240 x 320	3.2" (120dpi) - 4" (96dpi)	Microsoft PDAs
320 x 240	5.7" (70dpi)	vertical handhelds
640 x 240	5.5" (123dpi) - 8.1" (83dpi)	vertical handhelds & clamshell PDAs
640 x 480	6.0" (133dpi) - 10.4" (77dpi)	vertical handhelds & tablets
800 x 600	6.7" (150dpi) -10.4" (96dpi)	vertical handhelds & tablets
1024 x 768	10.4" (123dpi) - 12.1" (105dpi)	vertical tablets
1024 x 768	10.4" (123dpi) - 15.1" (84dpi)	rugged & consumer notebooks
…	…	…
1.920 x 1.200	17.3" (130dpi)	professional notebooks

Typical display sizes and resolutions

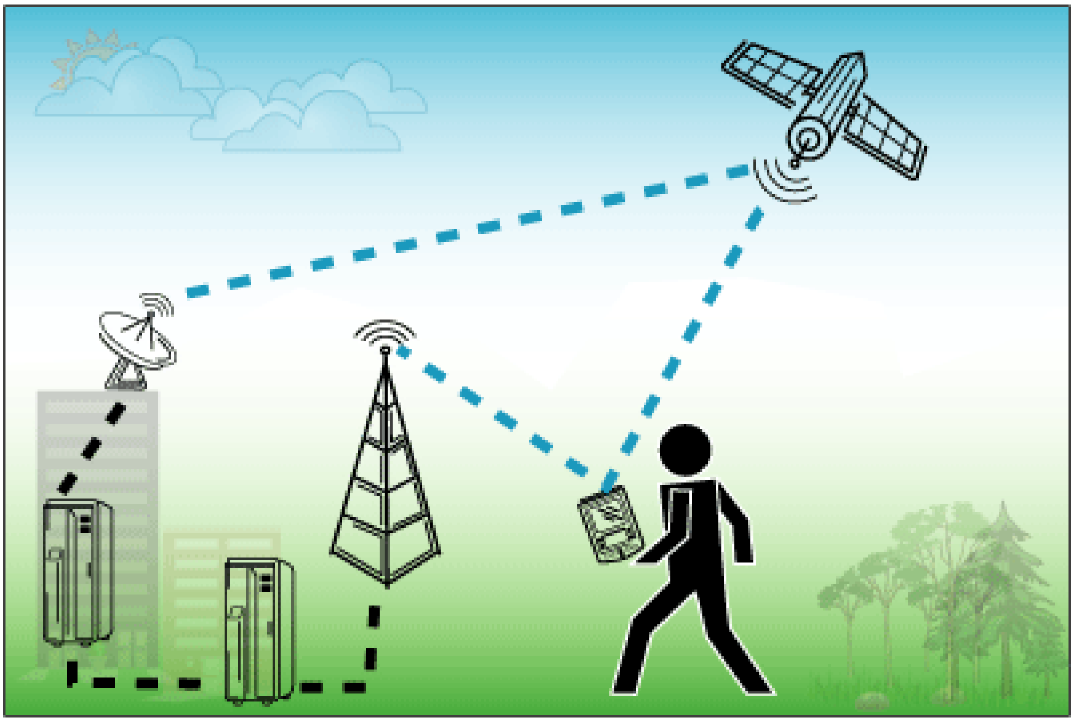
1.2. Networks & Positioning

Learning Objectives

- You will be able to list the major wireless network types.
- You will be able to relate from the wireless network range to the possible use in a LBS.
- You will be able to explain what positioning methods are available for LBS and how they work basically.

In order to establish a location based service the position of the user has to be known. Depending on the type of the LBS different accuracies are needed. Some LBS require only a position accuracy of hundreds of meters or even kilometres while others require the exact position at some decimetres. According to these needs also different positioning methods are available like satellite based GPS solutions or mobile phone based cell positioning solutions.

The idea of location-based services includes the communication or data exchange possibility between the different components. There can be various mobile and fixed components in a LBS architecture. An example would be a stationary data provider which is accessed via a mobile terminal. Thus having both stationary and mobile devices only wireless communication technologies can be used for location based services.



Communication and Positioning as LBS Components

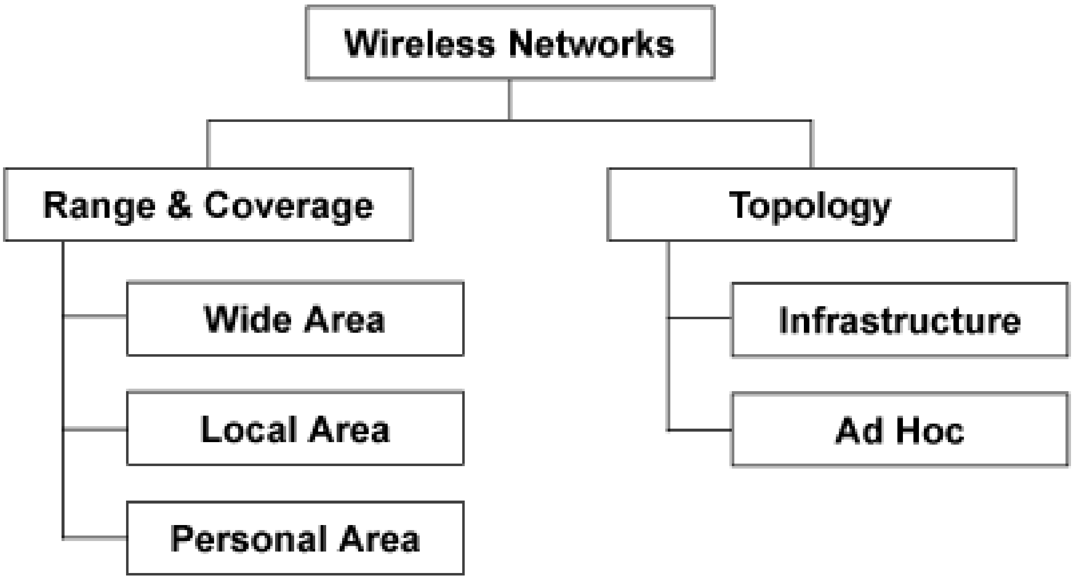
In this unit an overview about available and upcoming wireless communication as well as positioning technologies is given.

1.2.1. Wireless Networks

Establishing Wireless Network Communication

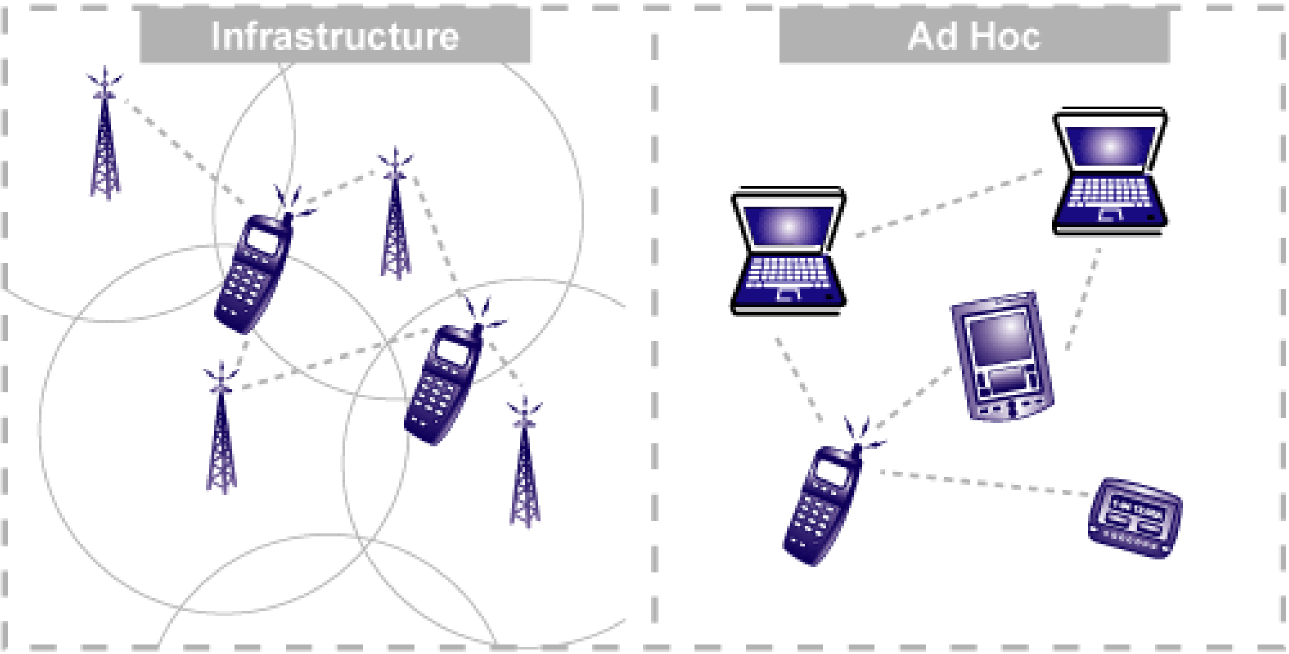
Wireless communication can be via different media such as ultrasound, infrared or electromagnetic radio waves. Radio waves are the most suitable for LBS as the other media have more problems e.g. with walls and other obstacles.

Common wireless networks today can be classified by two means. One classifier is the network range which is also induced by the network's purpose and the physical limitations of radio waves. The other classifier is the networks topology, whether the network consists of a large infrastructure of mostly im-mobile network-nodes and the mobile clients access only the nodes or the clients form an "Ad-Hoc" network by beeing the nodes themselfes.



Classification of Wireless Networks

Wireless Network Topologies
Radio waves do have a limited range. No matter which technologies and thus what ranges can be reached with a wireless radio transmission, for establishing communication between multiple components as a network three strategies are available: *cellular infrastructure networks*, *Ad-Hoc networks* and *hybrid networks*.



Infrastructure and AdHoc Wireless Networks

Cellular Infrastructure Networks are probably the most common way of overcoming the limited range problem. The mobile terminals, e.g. cell phone or PDA, communicate with base station. The base stations themselves are again connected to a network which can also be connected to other networks like the internet. Cell phone technologies like GSM work exactly this way. Usually is the base station network covering a whole country. In dense populated areas there are usually more base stations then on the countryside where fewer buildings or other obstacles are interfering with the propagation of the radio waves.

Ad-Hoc Networks are linking devices like computers or PDAs directly without a base station or access point. Common examples are Bluetooth devices communicating with each other or mobile computers which use just their wireless network capabilities to exchange data directly. To overcome the limited range problem, devices can not only do their own communication but act also as a relay-station and forward other messages.
Hybrid Networks are combining the two above technologies. Thus a cellular network can be extended into regions where no base station is reachable. The base stations can also then provide access to other networks like the internet.

1.2.2. Wireless Coverage

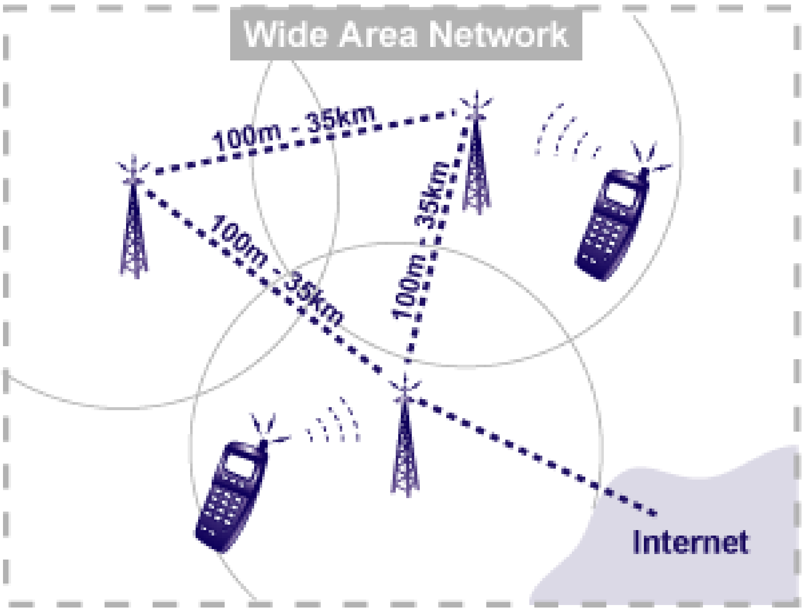
Wireless Network Ranges
Wireless networks can be classified by the network topology (see **Wireless Networks**) and by the range or coverage. When covering wireless networks by the *covered area* the following three categories are common:

- **Wireless Wide Area Network** (WWAN) - e.g. GSM and UMTS
- **Wireless Local Area Networks** (WLAN) - e.g. IEEE 802.11
- **Wireless Personal Area Networks** (WPAN) - e.g. Bluetooth

Most WWAN and WLAN are established as infrastructure networks, thus they consist of a mobile terminal and a base transceiver station. For WWAN a structured network (backbone) of such base stations is necessary. Since every base station covers a specific area does call such network types also *cellular networks* . Usually the network cells for WWAN overlap only by small portions.
Wireless Wide Area Network cells covering distances of 100 meters up to 35 km. The used frequency spectrum is usually not free, which means it has to be licensed, but can also not used by somebody else. WWAN networks emerged from cell based mobile voice communication networks. Generations of wide area networks:

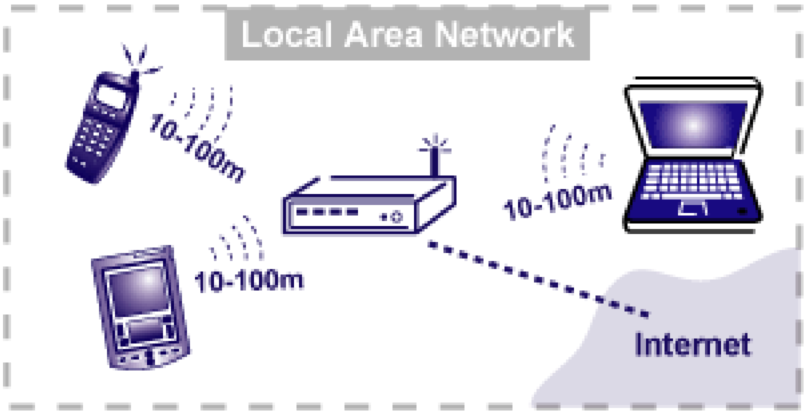
- Generation 0 (0G): analogue, radio cells with no handover
- Generation 1 (1G): analogue, unique calling number
- Generation 2 (2G): digital (GSM), datarate 9.6 –14 kbps
- Generation 2.5 (2.5G): digital (GPRS), datarate 20-115 kbps
- Generation 3 (3G): digital broadband (UMTS), datarate up to 2 Mbps
- Generation 4 (4G): digital, IP based, not yet available

Currently 2G and 3G communication networks are in use. Comparing existing GSM and UMTS techniques the latter network type needs much more base stations. Further the radius of UMTS cells is not constant since the coverage depends on the number of mobile clients and used data rates. A disadvantage of UMTS are higher network costs compared to G2 networks. Advantages of UMTS apart higher data rates are better data security (128bit encoding) and also better positioning capabilities (Hoffmann 2002).



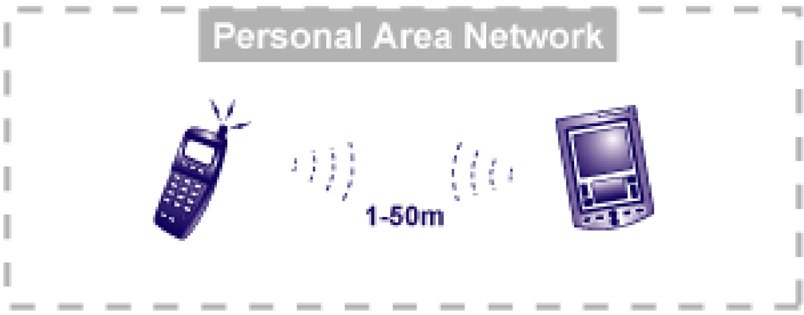
Typical Mobile Phone WWAN

Wireless Local Area Networks covering distances between 10 m to 150 m (300m outdoor). They use the unlicensed spectrum and provide much higher data transfer rates (100 Mbps) than WWAN. Since WLAN technology emerged as extension to Computer LANs the network is specialized on data transfer. Mobile stations connected by WLANs can use simple infrastructures with Access Points (APs) instead of Base Stations or can connect to one another directly in ad hoc mode (Krishnamurthy et al. 2004)



Typical Home WLAN

Wireless Personal Area Networks provide short range connectivity e.g. for digital cameras or headsets. The covered area radius is about 10m but will increase up o 100m in future. The used frequency spectrum is unlicensed and data rates are about 0.5 Mbps, thus in between WWAN and WLAN. These devices connect and disconnect as needed and have therefore a so called ad hoc topology. Most WPANs are based on the Bluetooth standard. Advantages compared to WLAN are voice support and security issues (Mäs 2003).



Typical PLAN (e.g. Bluetooth)

Overview of Network Ranges and Transfer Rates

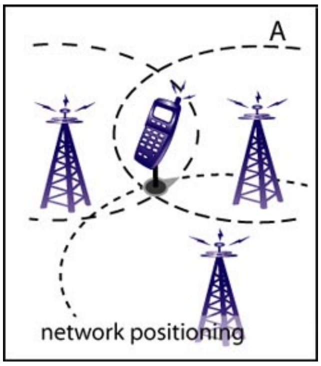
(2004) state that WLAN and WPAN are better suited for information services with high granularity (e.g. details of a room) and better suited for consumer portal services (navigation in a shopping mall or museum). In the opposite WWANs are likely to support large scale services like fleet management, safety, telematics and are therefore useful for smaller set of information services.

Network Technology		Average range	Data Rate (MbPs)	frequency domain
WWAN	GSM (G2)	base station distance 100m-35km	0.009-0.014	~ 900 MHz, licensed Spectrum
	GPRS		0.160	
	UMTS (G3)		0.384-2.0	
WLAN	Ultra-Wideband	10m	100	~ 2.4 & 5 GHz, not licensed spectrum
	IEEE 802.11a	50m	54	
	IEEE 802.11b	100m	11	
WPAN	Bluetooth	10m	1	~ 2.4 GHz, not licensed spectrum
	HomeRF	50m	10	
	IrDA (infrared)	1-1.5m needs line of sight	1-16	not licensed spectrum

Properties of a selection of different wireless network technologies.

1.2.3. Positioning

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 Figure A below). Therefore the mobile device sends either a signal or is sensed by the network. The second positioning group is called *terminal-based positioning*. Here, the location is calculated by the user device itself from signals received from base stations. The most famous example for a terminal-based system is the use of the Global Positioning System (GPS). The base stations for the GPS system are the GPS-satellites (see Figure B below). Finally a third group of positioning techniques emerges from combination of network and terminal positioning techniques.



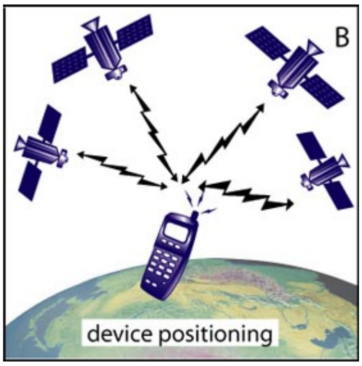
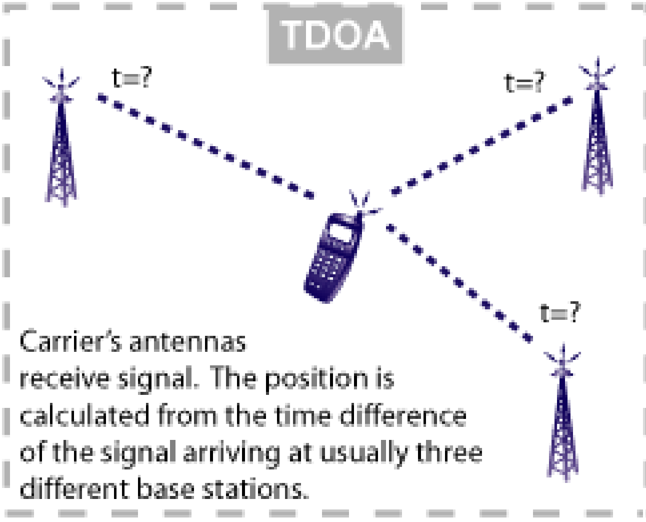


Figure A: network positioning *device positioning*

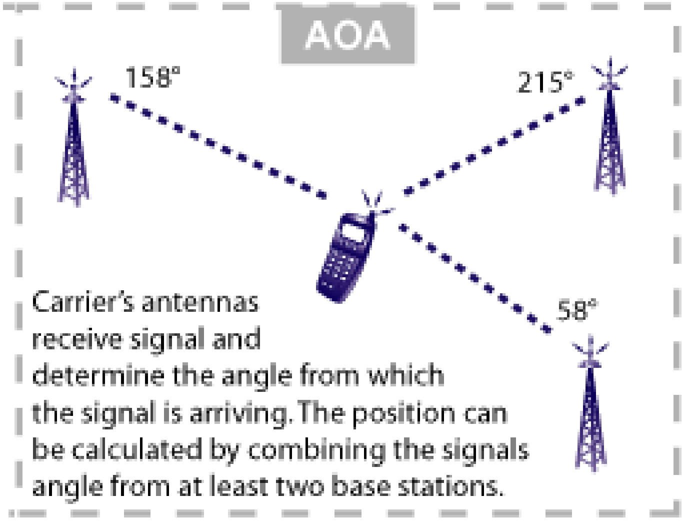
The basic principle for the calculation of the user position, valid for all groups, is that base stations have a known position at all times. Usually distances and/or angles from the sender to the receiver can be measured. The following basic techniques are often used for positioning, mostly in combination:

1. **Cell of origin** (COO), **Cell-ID**, **location signature**, **location beacons**: The cell of origin or Cell-ID is usually the identifier of the nearest base station, e.g. a mobile phone antenna. With this technique the position is known in a defined circle or cell around the base stations known position. In the context of mobile phone networks COO is usually termed Cell-ID. But COO positioning is also possible with other wireless networks such as WLAN or Bluetooth. Beacons, e.g. infrared, ultrasound or *RFID* [7], are used mostly indoors. Here beacons have an identifier id or transmit their exact position to the mobile device which is in reach.
2. **Time of Arrival** (TOA): As electromagnetic signals move with light speed. Knowing the speed and the time difference between sending and receiving the distance can be computed. Light speed is approx 300’000km/s thus the runtimes are very short and exact timers are needed. The same principle can also be used for slower signals like ultrasound.
3. **Time Difference of Arrival** (TDOA), **Enhanced Observed Time Difference** (E-OTD): these techniques do also compute the distance by measuring the runtime, but in difference they use therefore the time difference between the signals of usually three different base stations. Thus having signals from different neighbouring base stations the position can be triangulated. In the case of TDOA the calculation of the position is done by the network provider, in the case of E-ODT it's done in the mobile device.
4. **Angle of Arrival** (AOA), **Direction of Arrival** (DOA): by using antennas with direction characteristics the angle of arrival in the mobile device can be detected. Because of a moving mobile device this is not very exact. Another possibility is that many base stations have segment antennas (usually 2-4) which divide the circumcircle of the base station in segments of 90, 120 or 180 degrees.

[7] Radio Frequency Identification, An RFID tag is a transponder generally containing a antenna and a silicon chip containing information such as a uniquely identifying serial number. Thus it can serve as a radio beacon.

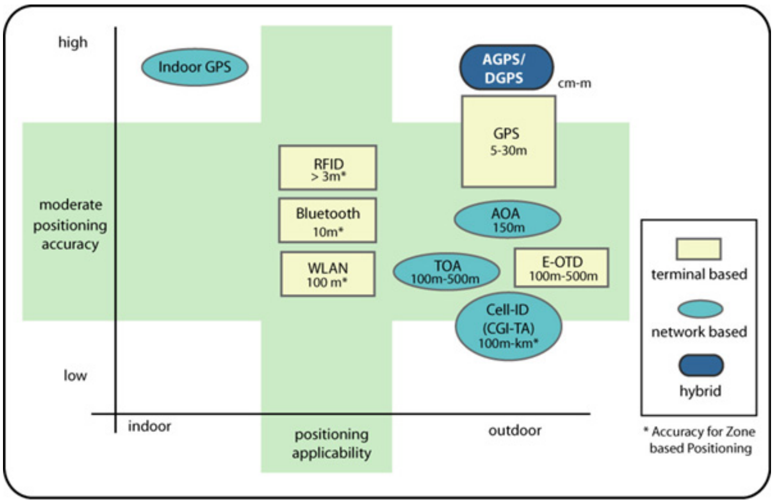


Time Difference of Arrival Positioning



Angle of Arrival Positioning

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 km). Especially GPS is (currently) a 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. The Figure shows a number of positioning methods with their accuracy and their applicability to indoor and outdoor user activities. As a rule over the thumb one can say on one hand that network positioning is useful for LBSs where precision is not critical. Here, the Figure below shows the usually lower positioning accuracy of network methods. On the other hand the terminal based positioning is to recommend for LBSs where precision is important: e.g. dispatch, driving directions or billing (Lopez 2004).



Positioning methods, accuracy and application. (AGPS: Assisted GPS, AOA: Angle of Arrival, TOA: Time of Arrival, E-OTD: Enhanced Observed Time Difference)

1.2.4. Self Assessment

Drag the Keywords into the right table-cells. Multiple identical keywords belong into different table-cells.

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

For the meaning of the Keywords have a look in **Positioning** or in the glossary: *AOA* [8], *Bluetooth*, *CELL-ID* [9], *DOA* [10], *EOTD* [11], *GPS* [12], *RFID*, *TOA* [13].

[8] Angle of Arrival, using antennas with direction characteristics.

[9] Identifier of the neares base station in a wireless network.

[10] Direction of Arrival, using antennas with direction characteristics.

[11] Enhanced Observed Time Difference, calculation of the distance to three base stations by measuring the signal runtime.

[12] Global Positioning System, based on data transmitted from a constellation of 24 satellites. At least 4 sattelites have to be in range for correct positioning by measuring the signal runtime from the sattelites to the device.

[13] Time of Arrival, knowing the speed and the time difference between sending and receiving the distance can be computed.

1.3. Data Formats & Map Response

Learning Objectives

You will be able to ...

- relate from different data formats to the role of map response in terms of usability and map response.
- to explain the influence of data caching and tiling on the map response.
- describe the advantages and disadvantages of raster and vector data formats for the use in LBS.

Many Location Based Services are a sort of extended web map service for mobile devices. Thus maps and other data are delivered via the internet to the mobile LBS device.
The map response and thus the usability of a map, displayed on a mobile device, are largely dependent on the different technical options such as the used data format and the number of layers to display. But also the image transfer and rendering influence the response of operations such as panning and zooming. They can be improved by using tiling and caching. These technical details will be explained in the following units.
For more details about graphic formats etc. have a look at the **Computer Graphics** lesson.

World Wide Wait (Sev Wide Web)

1.3.1. Map Response

Use the mobile map display below: The panning works just by clicking in the image and moving the mouse while the button is pressed. Adjust the the options (number of layers, tile level, choice of raster or vector) and experience how they influence the map response! The meaning of the options will be explained in the following units. In this example only panning is possible. All other buttons and functionalities like zooming or searching are disabled.
As a starting point have a look at two scenarios. In the worst case scenario select *Num Layer* = 3 *Tile Level* = 1 and *Vector* data format. As every additional layer in a vector image contains new data this results in a large image file for the display and thus in a bad response while panning. In a normal case scenario choose *Num Layer* = 2 *Tile Level* = 3 and *Raster* data format. All the layers are combined to one raster image and the tiling splits the image file into smaller entities which can be downloaded simultaneously. This results in an acceptable map response while panning.

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

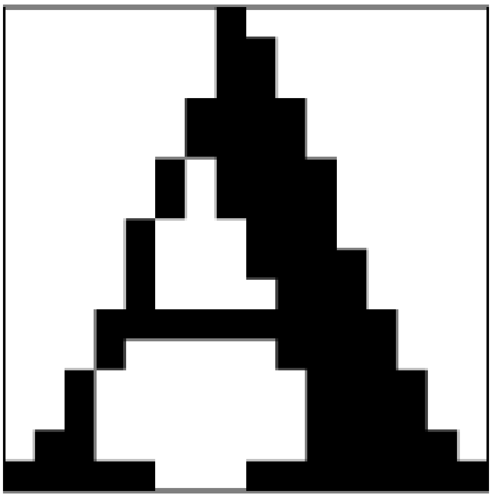
As seen in the example above there are different factors influencing the response of an online map, e.g. while panning or zooming. Influences due to different wireless network speeds are not covered in this example as they have already been discussed in the Unit **Networks & Positioning**.

1.3.2. Data Formats

Maps on computers of mobile devices are stored as graphics. There are two main format types for graphics and thus also for maps. These formats differ a lot in terms of applicability for different grapic types but also in file size and rendering speed. This and the following unit will give a short introduction in the capabilities and drawbacks while using raster or vector maps for the display on mobile devices. For more information about image formats check out the lesson **Internet Techniques and Web Formats** or for example the tutorial "*Looking Behind the Pretty Pictures*" (Peck) .

Raster Maps

A raster graphics image, digital image, or bitmap, is a data file or structure representing a generally rectangular grid of pixels, or points of colour, on a computer monitor, paper, or other display device. The colour of each pixel is individually defined; images in the RGB colour space, for instance, often consist of coloured pixels defined by three bytes—one byte each for red, green and blue. Less colourful images require less information per pixel; an image with only black and white pixels requires only a single bit for each pixel (WIKIPEDIA).

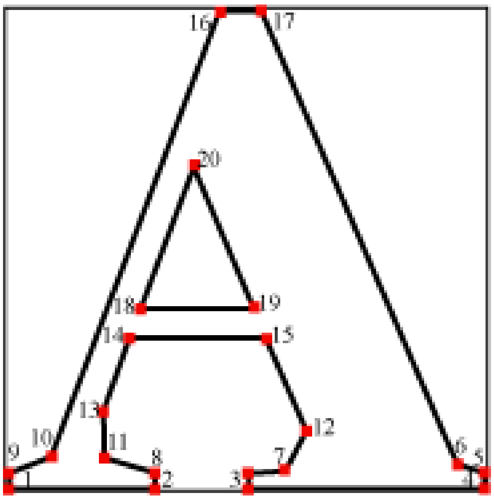


0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0
0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0
0	0	0	0	0	1	0	1	1	1	1	0	0	0	0	0
0	0	0	0	0	1	0	1	1	1	1	0	0	0	0	0
0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0
0	0	0	0	1	0	0	0	1	1	1	1	0	0	0	0
0	0	0	0	1	0	0	0	0	1	1	1	0	0	0	0
0	0	0	1	1	1	1	1	1	1	1	1	1	0	0	0
0	0	0	1	0	0	0	0	0	1	1	1	1	0	0	0
0	0	1	0	0	0	0	0	0	0	1	1	1	1	0	0
0	0	1	0	0	0	0	0	0	0	1	1	1	1	0	0
0	1	1	0	0	0	0	0	0	0	1	1	1	1	1	0
1	1	1	1	1	0	0	0	1	1	1	1	1	1	1	1

Raster Example

Vector Maps

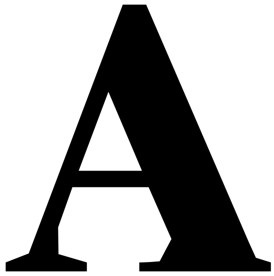
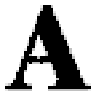
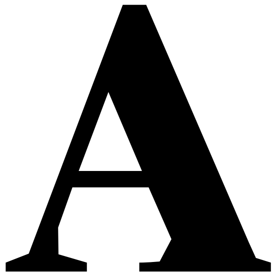
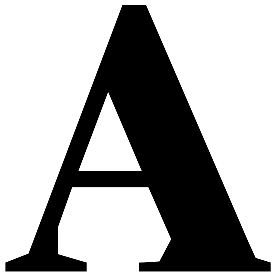
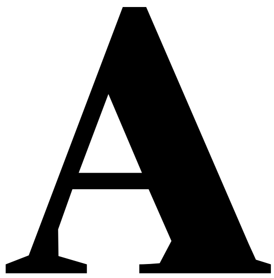
Vector graphics or geometric modeling is the use of geometrical primitives such as points, lines, curves, and polygons to represent images in computer graphics (WIKIPEDIA).

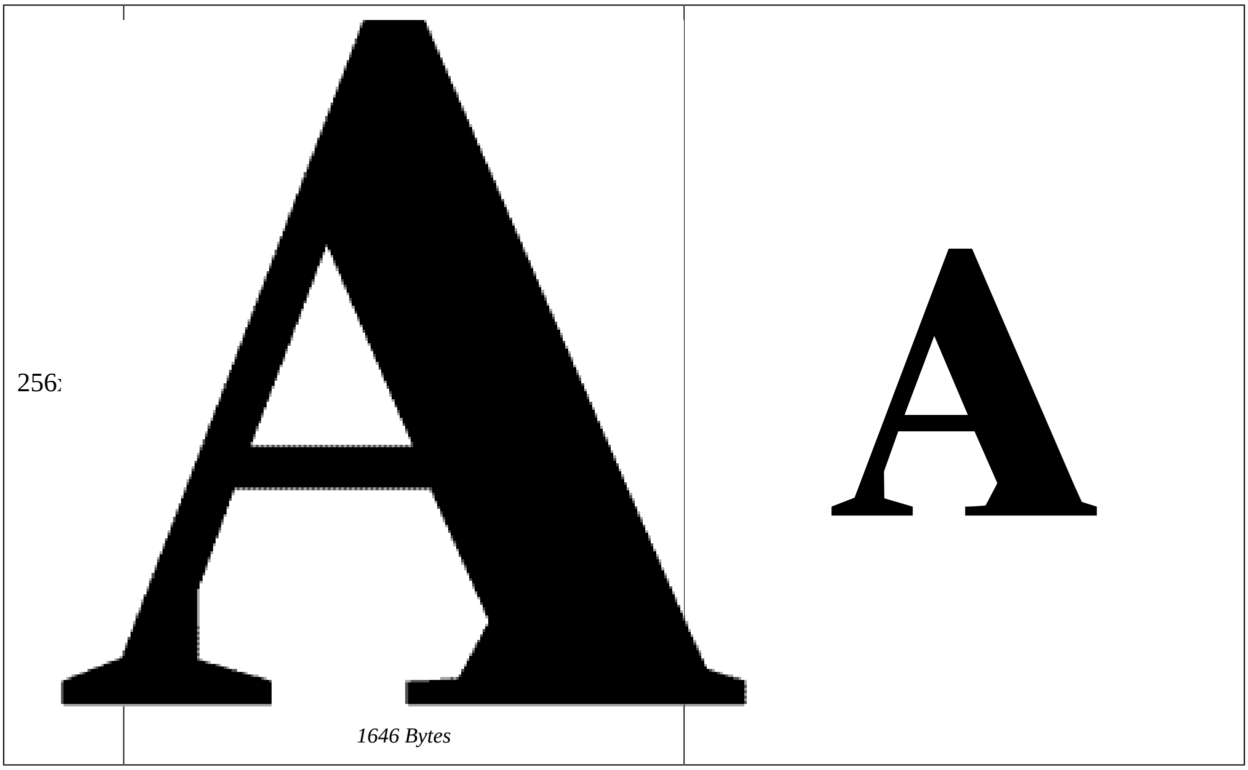


POLYGON((X_1,Y_1,X_2,Y_2,X_3,Y_3,
... ,X_{17},Y_{17}),(X_{18},Y_{18}, ... ,X_{20},Y_{20}))

Vector Example

The advantages of vector images seem obvious. While raster graphics are defined in terms of individual pixels, vector graphics only store coordinates, lines, curves and the fill or line colour. Raster graphics have a defined height and width and look pixelated if enlarged beyond these boundaries, vector graphics render themselves to the space given to them, such that they are resolution independent. Thus also the file size of a vector image remains always the same, independent of the size the graphic is displayed. A larger raster image however results always in a bigger file.

pixels	GIF	SVG
16x16	 *110 Bytes*	
32x32	 *188 Bytes*	
64x64	 *375 Bytes*	
128x128	 *780 Bytes*	



File size differences GIF - SVG

The size of a vector graphic is only dependent on the amount of information, coordinates, arcs, lines and polygons, that are shown in it. Thus vector graphics are especially suited for logos or illustrations were a limited number of objects and different colours are used.
As all graphics are visualised on a computer or mobile device display as raster (see **Computer Graphics**), every vector image has to be rasterized before it can be displayed. Thus on the one hand vector graphics often have smaller file sizes as a raster image and can be transfered faster to the mobile device. But on the other hand the mobile device needs more time for generating the displayable image. This issue will alse be discussed in the next section **Data Amount**.

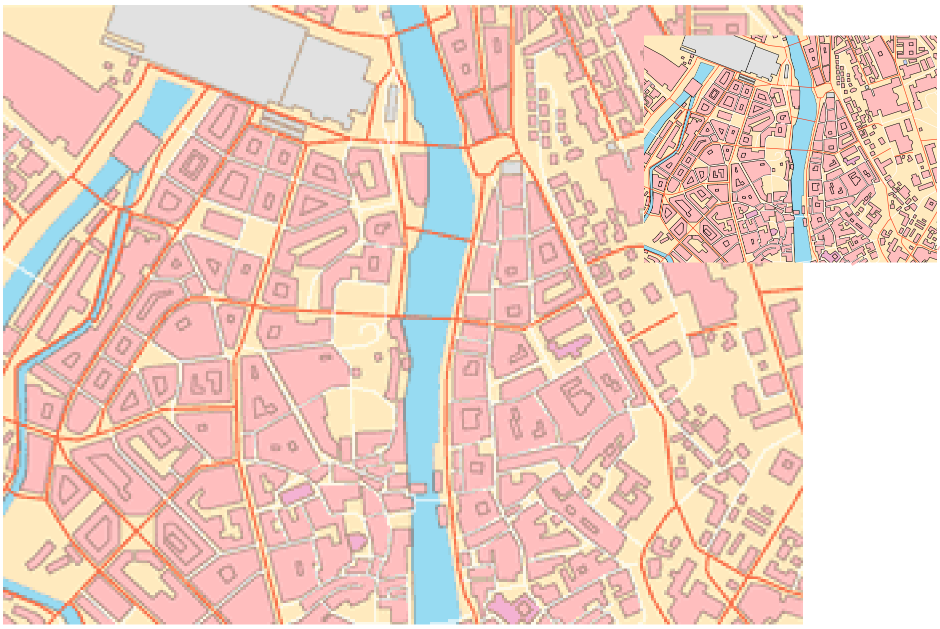
Why still using raster?
For images where almost every pixel contains different information such as photographs vector files are not appropriate. The vector file would be even larger than the same raster image.

raster photograph (JPEG 29.3KB)

The photographs above show the disadvantages of the vector format. Many different pixels as they occur with the colour gradients in an image are almost impossible to display in a vector image. When approximating a raster image a rather sketchy image is generated. Due to the large number of different polygons in the image the file size is even much larger than the raster. If you click with the right mouse button on the right image and choose "Zoom In" you can see that the vector image of the photograph consists of approx 2500 small polygons.

1.3.3. Data Amount

In the last unit the difference between raster and vector graphics were shown. The file size of a raster image is only dependent of the image size (amount of pixels). The file size of the vector image however depends only on the amount of information, thus on the amount of different objects, shown in the image. In most LBS scenarios the maps and other graphics are delivered from the service provider to the mobile device via a wireless network. Thus the file size of those graphics influences the transfer time and thus the map response.



raster map example (27KB)

The examples above show 829 map features (443 roads, 380 buildings, 6 surfaces). So at this display size the raster map (27KB) is much smaller than the vector map (81KB compressed, 335KB uncompressed). Thus the choice of the data format is also depending on the amount of information (map features) to display in relation to the size the map will displayed at. Vector graphics have no specific display size and can be displayed at every desired scale. This resizing can also be seen as zooming. All the information which is present in the vector graphic can be presented enlarged without having to download the graphic again. Click at the *vector map example* above and choose *Zoom In*. You can see how the vector map is enlarged and the single items are better to recognize. But there is no new more detailed information shown. Thus if new information, e.g. a map with more details, has to be displayed always new has to be downloaded (see table *map navigation and data transfers* below).

operation		**raster**	**vector**
	panning	download new data	download new data
	zooming (same map)	download new data	use old data
	zooming (other map)	download new data	download new data

map navigation and data transfers

Rendering of Vector Graphics

Computer displays are always showing rastered graphics. Thus a vector map has to be rendered (converted to raster, see lesson **Computer Graphics**) on the device, before displaying it. The processing speed as well as the memory is much smaller on a mobile device compared to a normal desktop PC. This lack of performance influences the rendering speed of vector graphics, e.g. in the SVG format:

"*What considerations should be taken into account when generating SVG content for mobile devices? As a very general rule, the fewer the number of graphics objects the faster the rendering speed.*" (Robinson 2002)

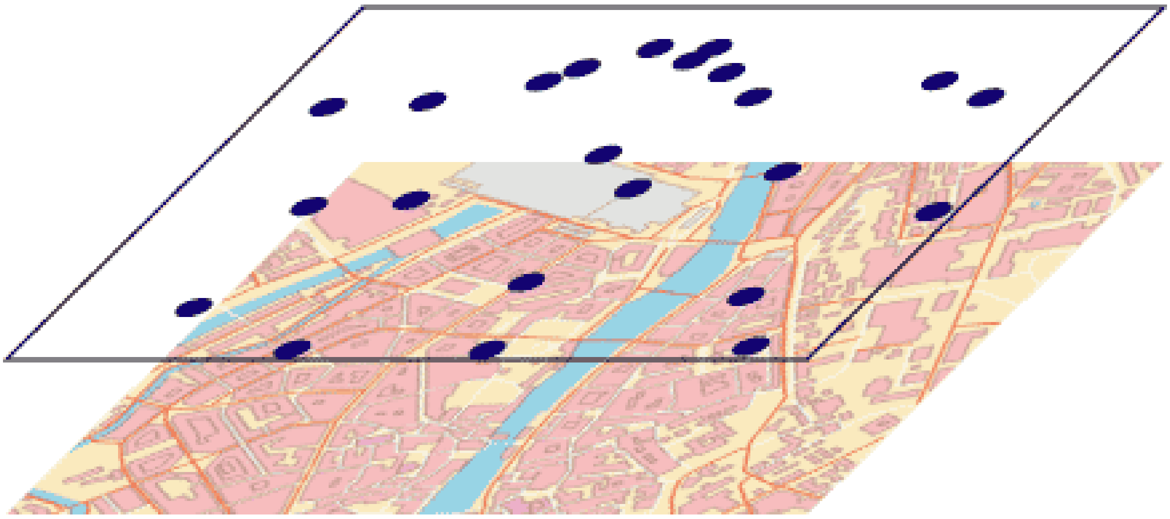
So again vector graphics are more suitable for graphics with a limited amount of graphic objects (map features). Exact numbers when vector and when raster is better are impossible to say because they depends on the purpose of the graphic. The performance of mobile devices is still raising with time so that soon also the rendering speed on mobile devices will increase.

Background and Foreground Layers

A common way of overcoming these rendering problems are for example the use of background and foreground layers. The background layers contain the map details that are not dynamic. An example would be a LBS map showing some *POIs* [14]. While the POIs are created dynamically for the specific request, the map with the topographic information such as roads and houses are static. Thus theis background information can be *cached* [15] on the mobile device instead of having it to reload with every new request.

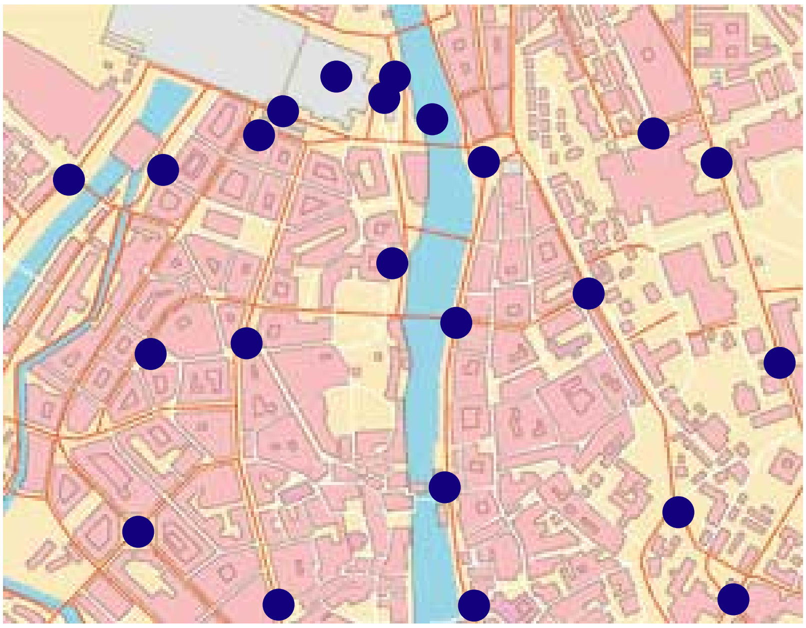
[14] Point of Interest

[15] When you download a web page or an image, the data is "cached," meaning it is temporarily stored on your computer. Thus the next time the page or image is just accessed from the cache, instead of requesting the file from the web server, so it loads quickly.



background raster map and vector POI overlay

The examples show how a raster background map can be combined with a vector foreground showing POIs. This combination of the different formats results in a good performance, as only the few POIs have to be downloaded and rendered dynamically, wile the raster background is only downloaded once and then cached.



This combination of different layers can also be done with multiple vector or multiple (partially transparent) raster images. Also a combination with tiling (see next section) in order to enhance the response is common.

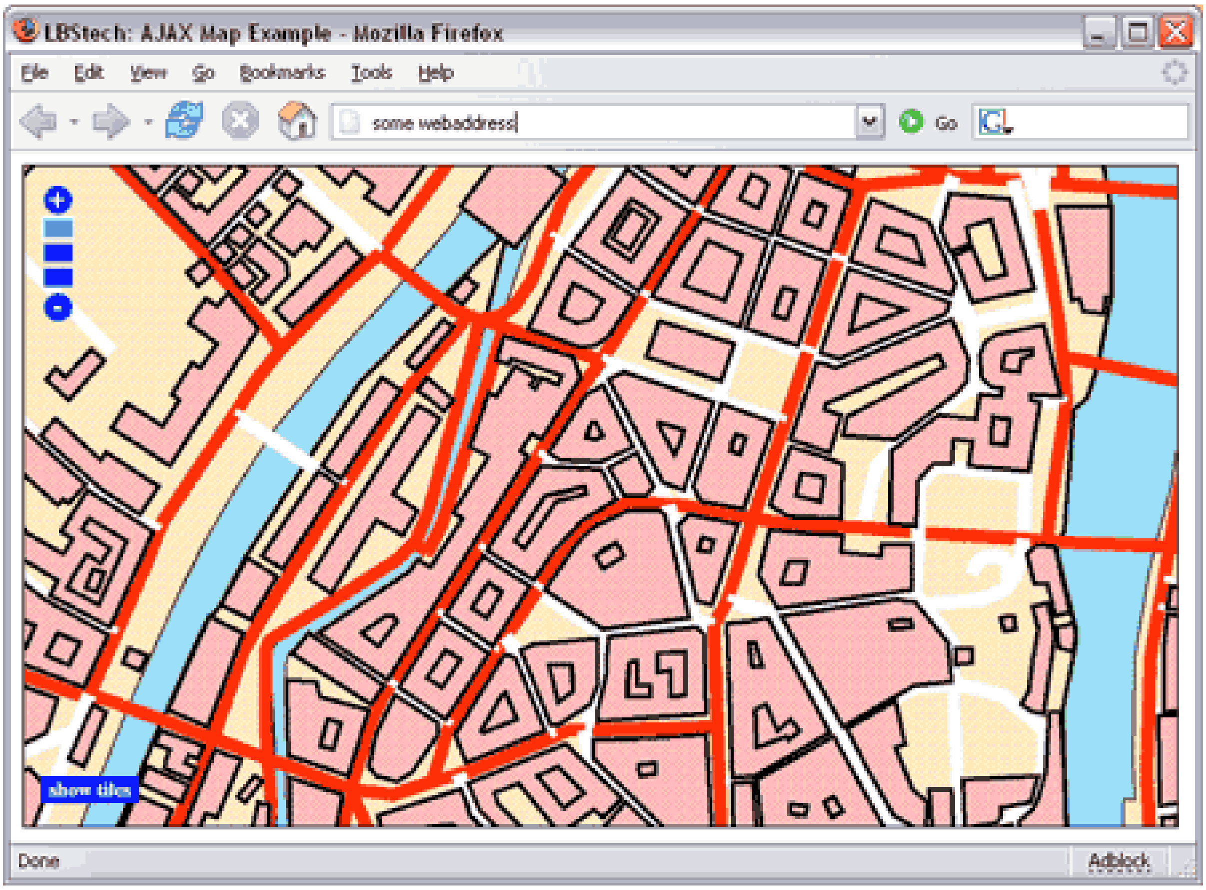
1.3.4. Tiling & Caching

As already pointed in the introduction, most maps for LBS are basically special web mapping services for mobile devices. So also the techniques used and the problems to solve are comparable for both.

When talking about web mapping the **Google Maps** seem to be almost a synonym for many people. When Google Maps were launched the simplicity and the smoothness of the map display was impressive. But in fact the concept behind is just a simple combination of well known techniques.

Web Map Experience

The following example shows a very simple web mapping application. Just click on the image and navigate in the map by dragging the map with the mouse. There are three zoom levels.



web map example

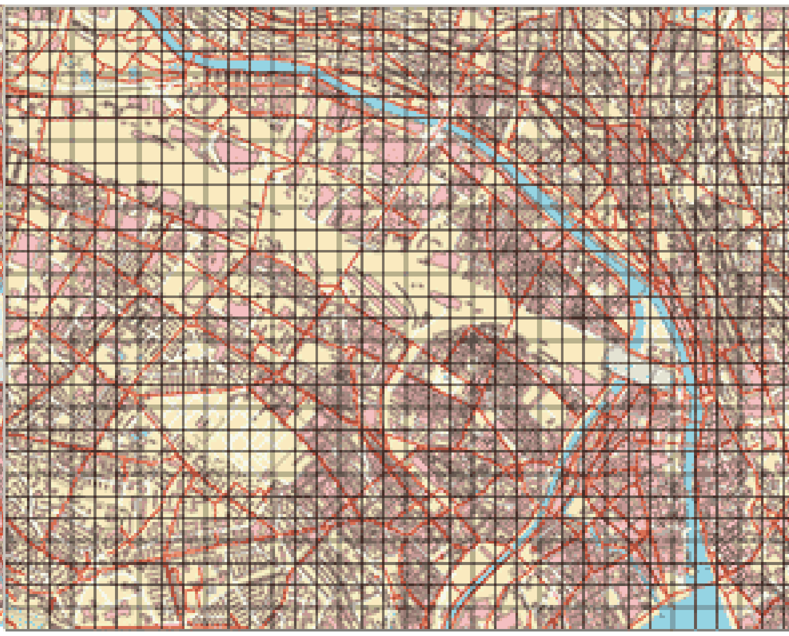
This web mapping example uses the same techniques than the map display in Google Maps. The technique behind is called *Ajax* and this stands for *Asynchronous JavaScript and XML*. If you want to know more about Ajax have a look at the web page **http://ajaxian.com/** or at the book "*Pragmatic Ajax*" (Gehtland et al. 2006) .

Basically in Ajax the web page which is displayed in a browser is modified in the browser with JavaScript instead from reloading the whole page from the server when content has changed. Only the new parts on the page have to be downloaded newly. In order to make the navigating (panning) in a map smooth tiling and tile caching are used.

Tiling

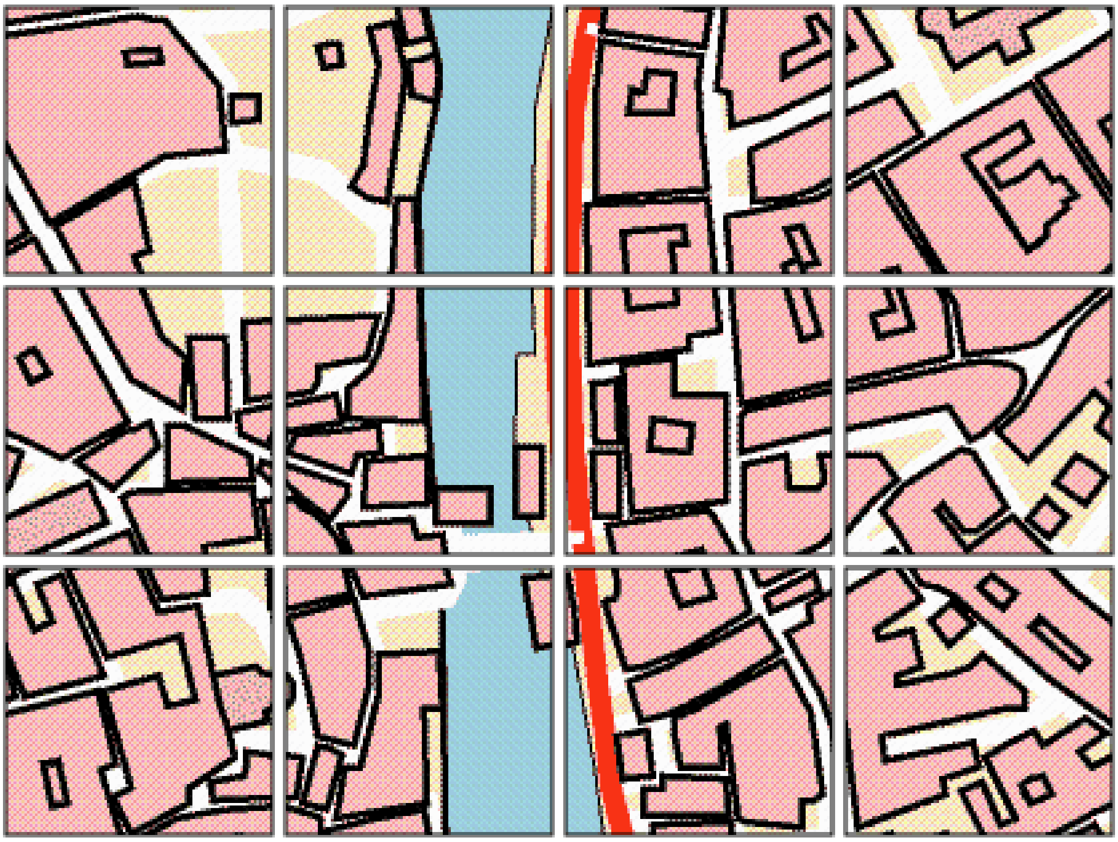
Going back to the web map example above: by clicking on the *"show tiles"* button int the lower left corner you can see that the displayed map image is split up in many small tiles. The original map has a size of 3600x2800 pixels. This is only a small map for demonstration. In a real system the source map could be much larger. A map covering a large city, a whole country or even the whole world would probably not fit onto a normal computer and never on a mobile device because of it's file size. Also the panning would be quite slow because of the file size.

city map overview (original size 3600x2800 pixels)



city map tiles (original tilesize 100x100 pixels)

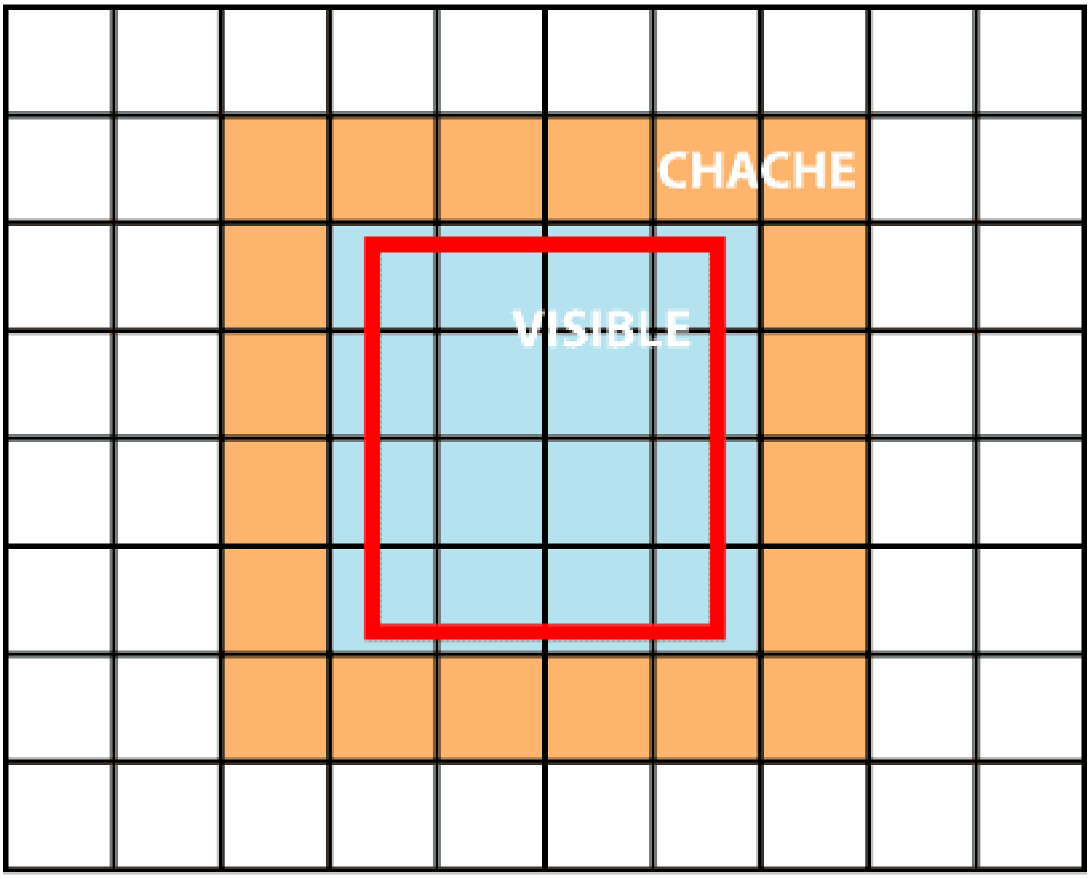
The original map is split into various tiles (usually quadratic). These tiles are laid out contiguously to form a cohesive image. In the example each tile has the size 100x100 pixels. So the image shown in the browser consists of a couple of tiles. Depending on the visible area of the map the tiles covering this area are displayed. So the remaining tiles covering the rest of the map don`t even have to be in the memory of the device but can be requested when needed due to panning. In the following image some tiles from the city map above are shown in their original size.



city map tiles detail

Prefetching and Caching of Tiles

All the tiles of the map are stored on the map server which provides the mapping service. Only the few tiles which are currently displayed need to be in the memory of the browser or LBS device. In order to enhance the panning speed and make it smoother some surrounding tiles can be downloaded in advance so that they are already in the memory when needed. Thus the prefetched tiles are stored in the *cache*.



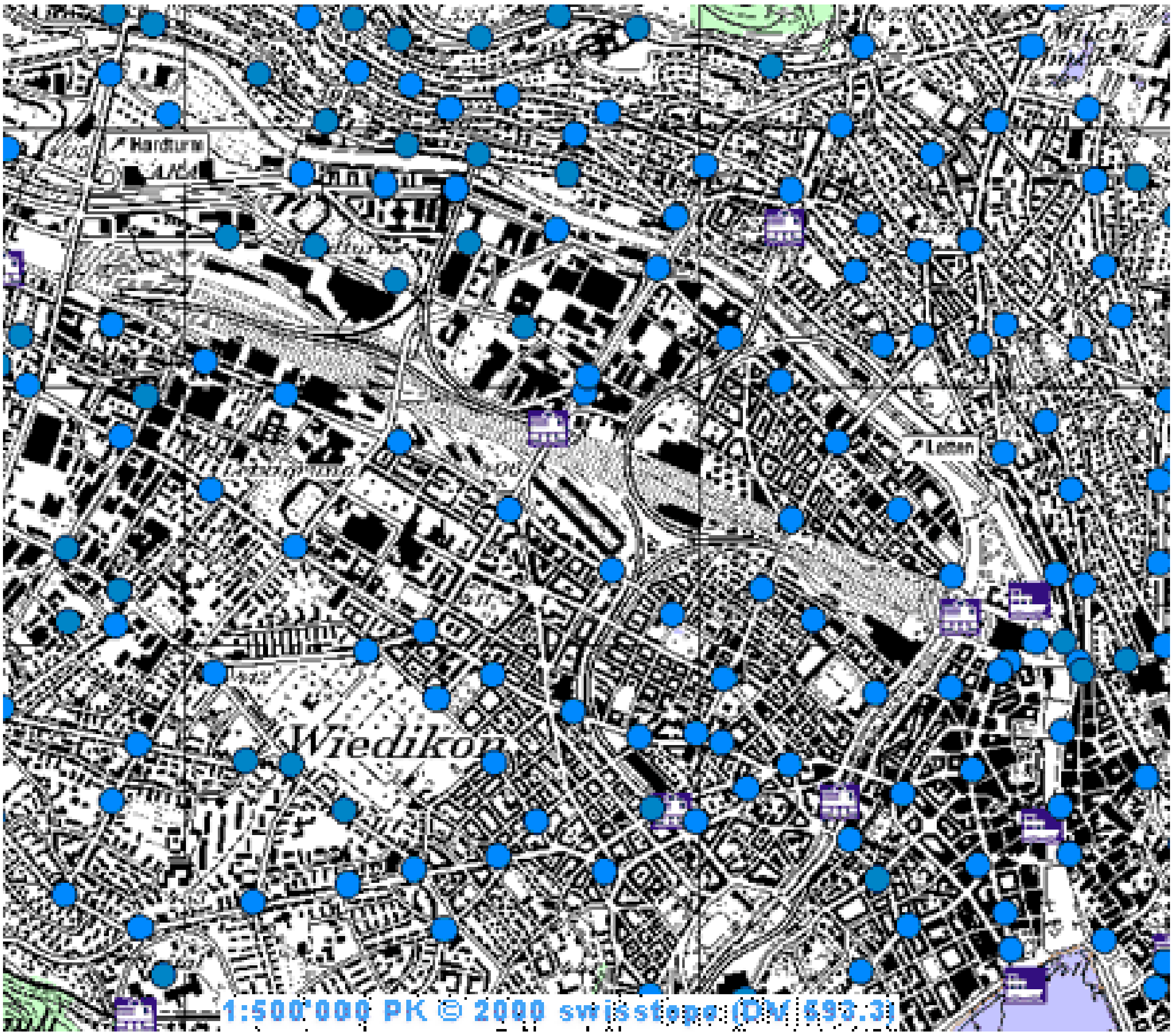
tile caching

Depending on the size of the visible area and the tilesize, the cached area can have different sizes. As users usually pan the map only by one third of the visibly size at once these tiles are prefetched and kept in the cache (see figure above).

1.3.5. Self Assessment

In this unit was shown how data formats, information amount and techniques like tiling and caching influence the map response. Discuss the two following map examples in the discussion board "Data Formats" of this lesson. Justify why you would use a raster or vector format and how that would influence the usability of the map. Therefore write a small comment (300-500 words) stating the differences of the two maps (map type, number visible layers, ...), which data format should be choosed and justify why.

example map 1



example map 2 (GIS-ZH)

1.4. Location Based System Architecture

Learning Objectives

You will be able to ...

- to describe the main components of a LBS System Architecture and how they interrelate.
- to identify the technical requirements of a LBS architecture.
- to describe the content types which can be displayed by a LBS and how they can be accessed.
- to list and explain the five core services defined by the OpenLS specification.

Considering the example of searching a Chinese restaurant the information chain from a service request to the answer will be described now and is visualized in the Figure 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.

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. When 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 search goal 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 sends 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 the 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 asking for such data from a **data provider**.
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 routing query (as 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.

1.4.1. System Requirements

Derived from the user actions, different requirements on the LBS system architecture emerge. Further different types of services are offered by companies to satisfy the needs. Whereas types of services will be described later we will start with the requirements on LBS. In opposite to Geographic Information Systems which are usually desktop or client server applications with a limited number of users, do LBS provide access and information to a large number of users. (2004) lists the following capabilities of LB-Services that usually exceed the general requirements on static GIS use:

- **High Performance:** Delivering answers in sub-second if querying information from internet and databases.

- **Scalable Architecture:** Support thousands of concurrent users and terabytes of data.
- **Reliable:** Capable of delivering up to 99.999 percent up-time.
- **Current:** Support the delivery of real-time, dynamic information.
- **Mobile:** Availability from any device and from any location.
- **Open:** Support common standards and protocols (HTTP, Wireless Application Protocol - WAP, Wireless Markup Language - WML, Extensible Markup Language – XML, Multimedia Markup Language – MML).
- **Secure:** Manage the underlying database locking and security services.
- **Interoperable:** Integrated with e-Business applications such as Customer Relationship Management, Billing, Personalization, and wireless positioning gateways.

These requirements lead to a complex LBS architecture involving a number of players. These Players include hardware and software vendors, content and online service providers, wireless network and infrastructure providers, wireless handset vendors and branded portal sites. Only common specifications and agreements among these players do ensure a user satisfying offering and deployment of services.

1.4.2. Requesting and Receiving Content

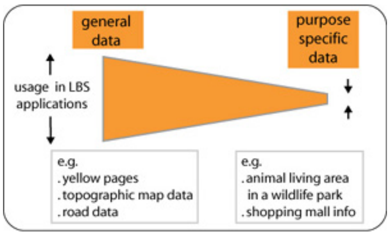
Push and Pull Services

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 only 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.

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.



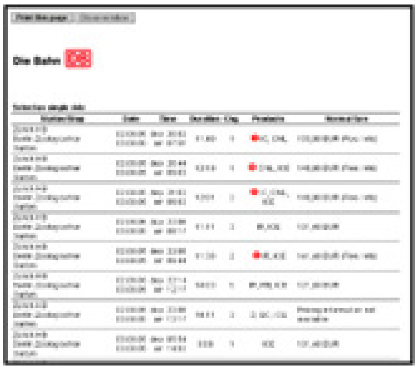
Purpose Specific LBS Applications are for instance services which help localizing handicapped people or services provided by a national park. For the first example, monitoring handicap people, only the position and mapping data is necessary, to display the person's position on a map. Further the monitoring 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?* can probably be found in the park's **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. Considering the core services types of the previous sub section we can allocate different data providers:

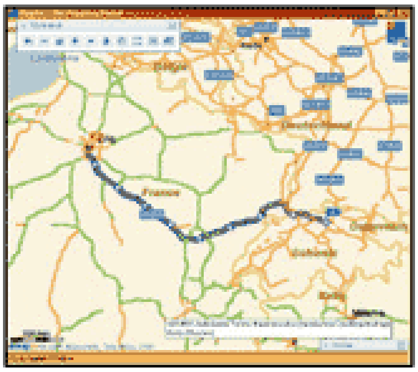
- *Directory Service*: Yellow Pages provider with local, national and international focus; transportation companies (rail and bus); Internet search services (e.g. Google.com, Yahoo.com); Internet consumer information services (Ciao.com) and Personal Websites (restaurant website, company website); electronic libraries like Wikipedia (**www.wikipedia.org**); weather services; entertainment and news information services; and so forth.
- *Gateway Service*: positioning services / position providers.
- *Location Utility Service*: provider of postal data (National Post Agencies) and street data (NAVTEQ, Tele Atlas).
- *Presentation Service*: aerial and satellite photo provider (National Space Agencies, National Surveying Agencies) and map provider (National Mapping Agencies, mapping companies and publishers).
- *Route Service*: street data providers (NAVTEQ, Tele Atlas, National Road Administrations) and routing services which can be combined with presentation (mapping) services (e.g. Michelin.com, Map24.com).
- The *non core service function* "Friend Finder" does not necessary need external information. Here, the position of friends can be determined by using solely mobile network information. In contrast, other services like "Real-Time Traffic" information could be directly exchanged between specialized data provider and user, without needing any additional data sources and processing, after obtaining the location from a positioning service.

The integration of the data - so called *data conflation* - from the mentioned different providers needs the definition of suitable data exchange formats and interfaces. The data conflation will be one of the challenging tasks for the next years.

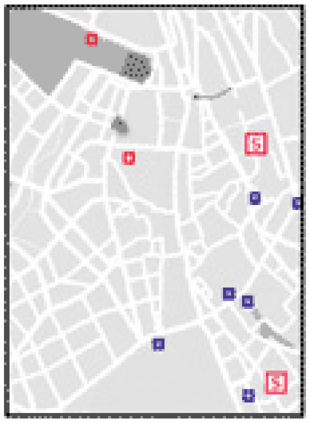
Different data for LBSs from various data providers:



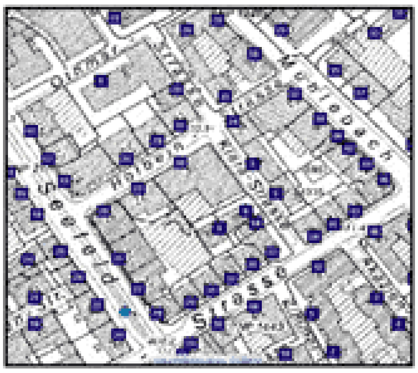
transport timetables (www.bahn.de)



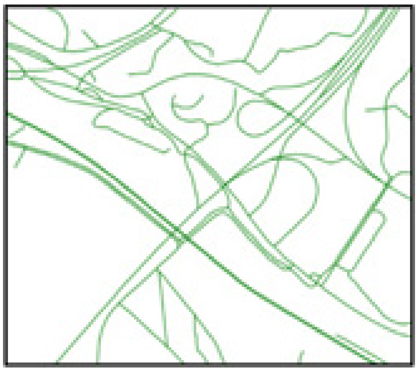
routing & traffic data (www.map24.de)



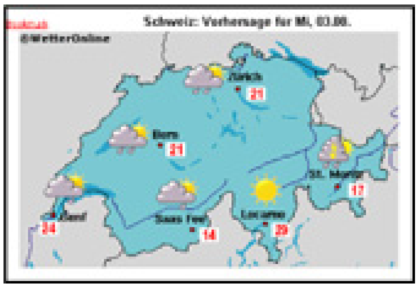
points of interest (restaurand, book store)



postal data (www.gis.zh.ch)



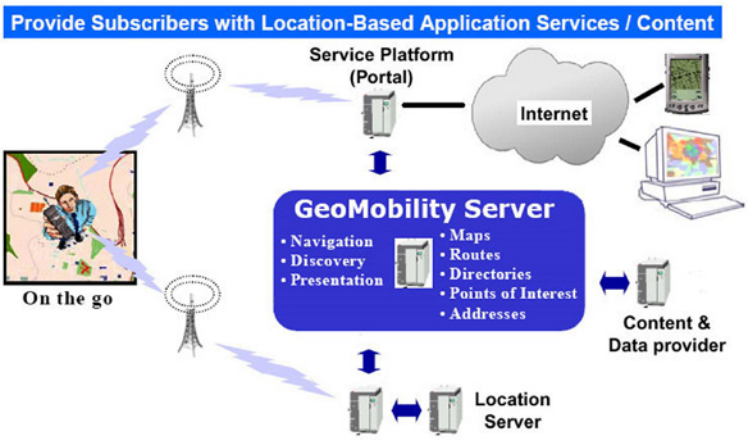
road network data



weather data (www.wetter-online.de)

1.4.3. OpenLS Services

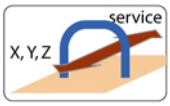
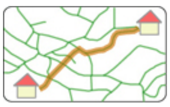
In the previous sub sections we discussed requirements and necessary components of LBSs. To realize a Location Based Service a number of different players ranging from technology providers to data providers have to be involved. This includes hardware and software vendors, content and online service providers, wireless network and infrastructure providers, wireless handset vendors and branded portal sites. To ensure that all the different technologies and devices work together common standards for interfaces and description have to be defined. Such standards with respect to LBSs have been set up by the International Standard Organisation (ISO) and by the Open Geospatial Consortium (OGC). Whereas ISO 19119 provides a general service framework and ISO 19101 gives a classification of geographic services, has the Open Geospatial Consortium released a specification for *Open Location Services* (OpenLS - (Open Geospatial Consortium 2005)). OpenLS defines core services, their access and abstract data types which form together a framework for a open service platform, the so called GeoMobility server. The server acts as application server and should proceed and answer core service requests. The role of this server is pictured in the figure. It should be noticed that service requests to a GeoMobility server can be send from a mobile user, from Internet users but also from other application servers.



The role of the GeoMobility Server. (modified version from OGC OpenLS Specification 1.1, 2005) (Open Geospatial Consortium 2005)

The core services defined in the OpenLS 1.1 specifications (Open Geospatial Consortium 2005) OGC 2005 include five service types:

 *OpenLS Directory Service*	**Directory Service**(spatial yellow pages): This service provides subscribers with access to an online directory to find the nearest or specific place, product or service. • Example 1: “Where is the Red Dragon Chinese Restaurant?”

	• Example 2: “Where are Chinese Restaurants?” • Example 3: “Where is the nearest Chinese Restaurant to my hotel?” • Example 4: “Which Chinese Restaurants are within 500m of my hotel?”
 *OpenLS Gateway Service*	**Gateway Service**: This is the interface between the GeoMobility Server and the Location Server from the Positioning Service (see the Figure). It is useful to request for the current location with different modes (e.g. multi or single terminal, immediate or periodic position)
 *OpenLS Location Utility Service*	**Location Utility Service** (Geocode/ Reverse Geocode): This service performs as a Geocode by determining a geographic position, if a place name, street address or postal code is given. It also performs as a reverse Geocode by determining a complete, normalized place name/street address/postal code, for a given geographic position. • Example 1: Given an address, find a position. • Example 2: Drive to an address (position). • Example 3: Given a position, find an address. • Example 4: "Where am I?"
 *OpenLS Presentation Service*	**Presentation Service:**: This service renders geographic information for display on a Mobile Terminal. An OpenLS application may call upon this service to obtain a map of a desired area, with or without map overlays that depict Route Geometry, Point of Interest, Area of Interest, location, position and/or address. • Example 1: Joe User wants to see where his house is located on a map. • Example 2: Planning a family road trip, Joe User wants to see how get from his house in Calgary, Alberta, to the hotel he has booked in San Diego, California.
 *OpenLS Route Service*	**Route Service**: This service determines a route for a subscriber. The user must indicate the start point (usually the position acquired through the Gateway Service, but this could also be a specified location, e.g. their home for a planned trip), and the endpoint (any location, like a place for which they only have the phone number or an address, or a place acquired through a search to a Directory Service). The subscriber may optionally specify waypoints, in some manner, the route preference (fastest, shortest, least traffic, most scenic, etc.), and the preferred mode of transport. The returned routing information can be textual, in a presentation code (describing turns and distances) or a geometry, useful for a map.

These mentioned services are core services, that means different providers will implement further services for their customers. Examples therefore are real-time traffic information, event guides and friend finders.

1.5. Recommended Reading

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1.6. Glossary

AOA:
Angle of Arrival, using antennas with direction characteristics.

Augmented Reality:
is a field of computer research which deals with the combination of real world and computer generated data. At present, most AR research is concerned with the use of live video imagery which is digitally processed and "augmented" by the addition of computer generated graphics. Advanced research includes the use of motion tracking data, fiducial marker recognition using machine vision, and the construction of controlled environments containing any number of sensors and actuators.

Bluetooth:
A wireless technology developed by Ericsson, Intel, Nokia and Toshiba that specifies how mobile phones, computers and PDAs interconnect with each other, with computers, and with office or home phones. The technology enables data connections between electronic devices in the 2.4 GHz range. Bluetooth would replace cable or infrared connections for such devices

Cache:
When you download a web page or an image, the data is "cached," meaning it is temporarily stored on your computer. Thus the next time the page or image is just accessed from the cache, instead of requesting the file from the web server, so it loads quickly.

CELL-ID:
Identifier of the neares base station in a wireless network.

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.

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)

DOA:
Direction of Arrival, using antennas with direction characteristics.

EOTD:
Enhanced Observed Time Difference, calculation of the distance to three base stations by measuring the signal runtime.

GPS:
Global Positioning System, based on data transmitted from a constellation of 24 satellites. At least 4 sattelites have to be in range for correct positioning by measuring the signal runtime from the sattelites to the device.

LCD:
Liquid Crystal Display, LCDs utilize two sheets of polarizing material with a liquid crystal solution between them. An electric current passed through the liquid, causes the crystals to align so that light cannot pass through them. Each crystal, therefore, is like a shutter, either allowing light to pass through or blocking the light.

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 (2004).

PDA:

Personal Digital Assistant, also known as Handheld Computer, Personal Information Manager (PIM),or Pocket Computer. A small, handheld device capable of storing appointments, adresses, documents, messages. PDAs can also function as a cellular phone, e-mail device, Web browser and personal organizer. Unlike portable computers, most PDAs began as pen-based devices that used a stylus rather than a keyboard for input. Many PDAs subsequently incorporate handwriting recognition features.

POI:

Point of Interest

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.

RFID:

Radio Frequency Identification, An RFID tag is a transponder generally containing a antenna and a silicon chip containing information such as a uniquely identifying serial number. Thus it can serve as a radio beacon.

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

STN:

Super Twisted Nematic. Viewing range 180°. Most common LCD type. The wide viewing range and high contrast makes it a good choice for many applications. Commonly available as very dark blue on yellow/green or grey background. As it is made in volume, cost is comparable to lesser types in all except highest volume.

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? and others..

TFT:

Thin-Film Transistor, technology for active-matrix screens in laptops, PDAs and cell phones. TFTs are composed of a matrix of pixels. The thin-film transistors act as switches for turning the pixels of the screen individually on and off.

TOA:

Time of Arrival, knowing the speed and the time difference between sending and receiving the distance can be computed.

User Interface:

Is a person using a PDA or mobile phone or something else? How can the user or (navigation) system formulate the needs and specify them later if needed?

Visualisation:

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

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