

Location Awareness and Location Based Services – Part I

Positioning and Terminology

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Introduction

As mobile Internet devices and third generation mobile networks become reality, *Location Based Services* (LBS) are thought to be a major growth area. Providing information, context and services by using positioning technologies seeds the potential for new enablers and experiences for users and developers, as well as promising new revenue streams for operators and service providers.

Context Sensitivity (or Context Awareness) is the ability, of the mobile device, to be aware of the user's surrounding physical environment and state. Context-sensitive applications and services can then be developed to exploit the fact that the mobile phone (in our case) can inspect the environment, rather than the other way round (where only the network knows about the device).

A context-sensitive mobile device may supply applications with information on location, altitude, orientation, temperature, velocity, biometrics etc. *Location Awareness* is only a small but powerful subset of these contextual capabilities that such a device may have.

Services built on the location awareness capabilities of mobile devices and/or networks are usually referred to as *Location Based Services*.

In terms of novelty, location awareness is in many ways considered to be one of the most important new application domain and service enablers. Location awareness demands some fresh ways of looking at the capabilities of mobile devices and how they can bring to the mass market a whole new range of applications, that we haven't experienced before outside (and some times even inside) the research community.

Making any predictions on what the "killer" application or services will be at this stage is premature. In this article we shall visit some background information, in order to clarify and discuss certain issues in our effort to educate the developer community on LBS. Later, in a subsequent article we will discuss likely application scenarios and illustrate taxonomies that we can use to differentiate and identify location based applications and services.

Positioning Technologies in Brief

Today there is a vast array of so called 'positioning' technologies that are involved with the calculation of position in a space or grid, based on some mathematical model. The technology required for provision of automated location information to mobile devices has been in continual development for several decades. While the majority has its roots in military, naval and aviation applications, modern consumer technology is also raising to meet the challenges, specifically in the metropolitan environment.

Positioning means, in most cases, allow a mobile device to be aware of it's location with different degrees of precision and accuracy. Different means (and thus technologies) will demand different capabilities from the device, while they'll bring various constraints. Such constraints come in the form of power consumption, cost, autonomy, speed, networking, autonomy, processing and overall system complexity.

In most cases, users, developers and service providers are not interested in the particulars of the positioning technologies employed, but rather with understanding and making use of their capabilities.

What is of interest is what we can do with location awareness rather than how such awareness is implemented or delivered to the device. Nevertheless, developers and many times consumers need to appreciate the various sets of capabilities that modern mobile devices will offer.

Since it is quite difficult to present and analyse all of them here, the following is a non-exhaustive high-level device-centric taxonomy.

Currently for 3G and 2.5G there are three main families of *Positioning*

1. GPS based

These are like the ones found on stand alone GPS receivers and network Assisted GPS devices.

An important clarification to have in mind for A-GPS, is that there are basically two types:

- First, there are those where the network assists the mobile device to make the final position calculation (the so called 'fix').
- Second those where the fix is calculated by the operator's network with the assistance of information from the handset - which is only at the end communicated back to it.

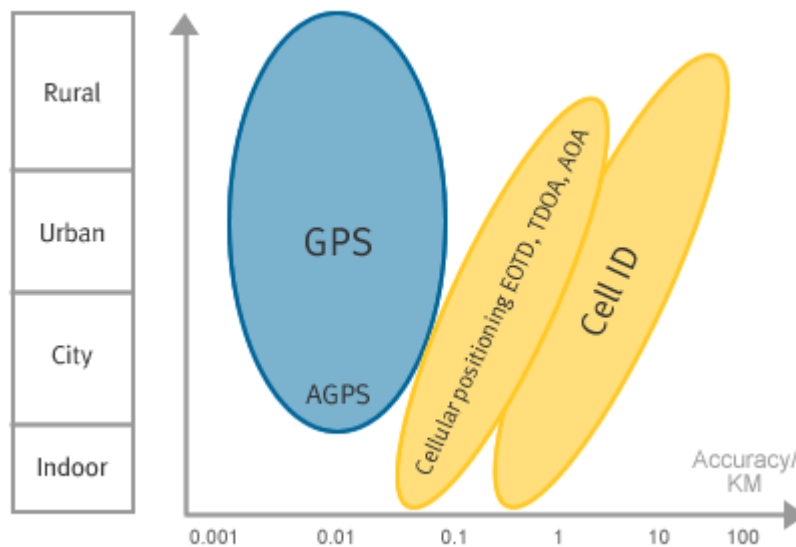
2. Network oriented using some form of triangulation

Triangulation techniques such as the ones found in E-OTD(Enhanced Observed Time Difference), TDOA (Time Difference of Arrival, AOA (Angle of Arrival), which use information from the base stations, are popular for deployment with 2G and 2.5G operators since most of the times involve an evolutionary upgrade to their network. These often don't even need any special functionality on the handsets (e.g., TDOA, AOA).

3. Network based that use Cell ID information plus some other radio signal measurements.

These include plain cell ID, cell ID combined with base station TA (Timing Advance) information or cell ID with RTT (Round Trip Time). These are techniques based on measurements of signal delays, round trip delays or signal jitter combined with Cell ID information, that can be deployed very cheaply on modern handsets.

Outside the remit of 2G, 2.5G and 3G cellular networks, exist other families of positioning technologies that are often referred to as 'local positioning', which usually make use of short range networks such as 802.11, Bluetooth, RFID, ultrasound, UWB or IrDA. Furthermore, recently there have been attempts to use positioning technologies based on TV radio signals.



Acquisition of positioning information - misconceptions

Many times, people will argue about the usefulness of location applications based on the merits of one positioning technology over another, in terms of attributes such as precision and accuracy (see below), while failing to recognise that suitability involves many more constraints. Such constraints are usually coupled within each specific application domain and cover diverse attributes, from the time needed to obtain the first fix (TTFF) to autonomy of the device and mode of operation under different physical surroundings or power consumption.

Many times, for example, it suffices for a location aware application to be useful for the user to manually input its approximate present location to the device, in simple symbolic representation (see below), while at other times a network operator and/or *Application Service Provider* (ASP) may offer location services to location-unaware devices over web services.

Another clarification as far as acquisition of location information goes, is that location enhanced emergency services such as the ones described by US E911 and EU E112 mandates do not necessarily mean that the user or developer will have access to positioning or any location service for that matter (other than of course user emergency calls). Operators and manufacturers which currently support E911 do not expose these device capabilities to developers. For that reason in almost all cases, users can not directly benefit or interact with LBS on such devices and networks. In many cases such devices may not even be location aware at all.

Positioning Concepts and Terminology

Following, are some concepts and jargon of location technologies worth mentioning in order to establish a common background and vocabulary when discussing LBS.

Physical position vs. symbolic location

Physical position is the actual position of an object within a frame of reference. For example, Symbian's Sentinel House is located at 51 °31'12.1" N, 000 °09'55.4" W, and washing up powder is at isle 6, 3 unit the local super market.

Symbolic location is related to abstract ideas, placing meaning onto an otherwise arbitrary location and within a contextual framework. Sentinel House is on Old Marylebone Road, near Edgware Rd tube station. The washing powder is beyond toilet rolls, at the checkout end.

Differentiation, thus, is between data and information. Each one has its benefits – generally simplicity of computation vs. meaning to humans.

Subsequently it is not possible to say that one is more important than the other. In many cases a physical position representation may have no value to humans without any symbolic information that in most cases places it within a known context (e.g., 51 °31'12.1" N, 000 °09'55.4" W may be good enough for a missile but not for a taxi driver).

Relative location

Everything is relative to a frame of reference. Absolute location is simply relative location within a well known (common) frame of reference (e.g., 0 longitude, 0 latitude).

Relative location can be spatially relative or temporally relative.

Spatially relative location is static: comparing where you are now to where some other object is now. If the spatially referred object is at a known absolute position, you can calculate your own absolute position.

Temporally relative location is dynamic: comparing where you are now to where you were at another time and is useful for temporal navigation, known as “Dead Reckoning” - from naval background. In fact, 0 longitude itself actually comes from a “common place” (Greenwich) from where to start dead reckoning.

The fourth dimension: time

Location systems often overlap with time systems, as the two are intermixed in certain location technologies (e.g., GPS, Round Trip Time), and are required to provide certain services (e.g., journaling). Navigation implies movement, which requires a passage of time and space, so positioning within time *and* space is part of location services.

Map datum

Given a global frame of reference, a *map datum* defines how locations are positioned within it.

Map data are partially historical artifacts, from each country basing its maps around local reference points, as absolute positioning was very inaccurate; since even the units of measurement (e.g., foot, yard, mile) had local variance.

This has an analogy with “local time” in the days before telegraph, when time could only be coarsely synchronised by physically carrying timepieces between towns.

WGS-84 is the widely adopted standard *map datum* which is in part due to its adoption within GPS.

Any system that exposes positioning functionality - whether that is a device itself or some middleware component - uses some position format and a specific *map datum*. For example, assuming that a system uses the *WGS-84* mapping datum, there are many position formats for representing a location fix, of which one is very popular to humans. This is longitude and latitude in degrees and minutes hddd,mmm.mm; another one is in degrees minutes and seconds hddd.mm'ss.s. For computer

communication and processing the most popular one, seems to be the WGS-84 ECEF-based real valued position format, which looks like hddd.ddddd for every axis (x,y,z) – ECEF stands for Earth Centred Earth Fixed.

As said, every village or country may have yet another datum format and or grid system. In order to give an idea of how many there are, an entry level basic handheld GPS receiver may have 17 different grid formats (position formats) and 111 mapping datum formats.

Basically a *map datum* (which implies an origin for the calculations) denotes how we do the maths, whereas the positioning format denotes how we represent them. There are numerous ways of doing both.

Accuracy and precision

All quantitative properties provided by location acquisition technologies have a related accuracy (or error or tolerance) and precision (or confidence). Coarsely, the accuracy is a measure of how far off the data may be (e.g., +/-20 metres) and the precision is what statistical percentage of the time the actual (or measured) error will be within the accuracy estimate (e.g., 95% of the time). These are a function of the acquisition technology, and current (and maybe past) operating conditions. Qualitative information can only have a confidence.

In actual fact, this will be a graph of confidence over accuracy, forming some sort of curve, such as a Gaussian distribution, that will itself be a function of the acquisition technique in use. This, may also be a function of multiple dimensions in space. Further analysis of such issues is far beyond the scope of this article.

Application Scenarios

Unfortunately when talking about LBS, most developers and users think in terms of static user-initiated scenarios like finding the nearest taxi rank or getting a map proximate to the user's position. Although such applications of location awareness are indeed useful and can bring revenue to many service providers, it is somehow limiting the domain and range of the possibilities arising from location aware computing, especially in the context of mobile phones.

Granted these are early days and such services are limited and not widespread, while neither users nor developers have had time for education on the domain; nevertheless we need to think about LBS in terms of an enabling (infrastructure almost) technology, where location awareness is invisible and not an end in itself. In many cases, useful LBS can be achieved without high degrees of positioning accuracy or in fact availability. While for some use cases (e.g., certain games) only accurate positioning will do.

We shall discuss such application scenarios in the following article, while illustrating human-device-network interactions.

Further information:

<http://www.telematica.de/cgalies/>

<http://www.wgs84.com/>

<http://www.fcc.gov/911/enhanced/>

E112

WGS-84

E911