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Location, location, location . . . looking at the "L" word in location-based services

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Abstract

Intrinsic to any Location-Based Service (LBS) is the need for clients to know their location. This location may be very precise, or very imprecise indeed.

This presentation surveys the various technologies available today to provide location to LBS applications. These are mostly based either on mobile phone technologies, or satellite-positioning technologies, or a combination (hybrid) of both. The benefits and drawbacks of each location source are assessed, and in particular the suitability of GPS for "professional" (high-value) LBS is outlined.

The presentation concludes by examining the ways in which GPS technologies are evolving to address the needs of the professional LBS market.

Sources of Location for LBS Applications

By definition, all location-based services require some idea of the client's location in order to provide a service that is tailored to the needs of that client. But those location requirements can be enormously vague. For example:

- A customised weather report may only need to know which country you are in, or perhaps which county/canton/commune
- A traffic report may only need to know which road you are on
- An insurance quotation service may only need to know your approximate post-code

On the other hand, the location requirements of some LBS applications can be incredibly precise, for example:

- A manhole location service may need to know your position to a meter or so
- A cable relocation service may need to know your position to 10cm or better

So there's a clear continuum of location requirements that need to be catered for. And it's reasonable to expect that different technologies may be needed to address different ends of this continuum. The appropriate location solution for each type of LBS application will of course be determined by the business economics associated with the application.

Legislation: Another "L"

But overhanging LBS is a requirement entirely unrelated to business constraints. And this, to some extent, is distorting the technologies being developed to meet commercial LBS application needs. The requirement in question is the American "E-911" legislation. This is a reference to the Emergency number you call if you require an ambulance, police or fire brigade in the United States. Today, if you call 911 from a fixed-line phone, the emergency services know where you are located (which building you are in at the time of making the call). But if you make a 911 call from a mobile cellular phone, the emergency services don't know which planet you're on, let alone how to quickly come to your aid.

The E-911 legislation is mirrored here in the EU (E-112). And while many people are aware of E-911, few seem to appreciate exactly what the law requires. Quoting from the legislation, all mobile telephones sold in the United States must provide the caller's location:

- To within 50m for 67% of calls
- To within 150m for 95% of calls
- Within 30 seconds of the call commencing

These are demanding requirements, clearly. But they can be met with a variety of technologies available today. However the telecommunications industry is founded on extremely thin profit margins, and it has proven difficult to identify a technology that will meet these requirements without adding significantly to the cost of mobile phones or cellular networks.

The E-911 legislation initially called for all new mobile phones sold in the U.S. to be compliant by May 2001. This was extended to October 2001, but after the other "9/11" event (and not entirely unrelated to it), the deadline has been extended yet again.

There is no doubt that at some time very soon, your telephone will need to report your position when you make an emergency call. And this capability can clearly be leveraged for other applications, including many Location-Based Services.

So returning to the LBS location-requirements continuum, an LBS application may need to know where you are at the country level, or the county level, or the city level, or the street level, or the house level, or the level needed to locate a utility asset buried in the street. But overshadowing the actual requirement of the LBS application is the bald fact that E-911 legislation is mandating a level of location that's somewhere in the 50m range, most of the time. And this is having a considerable impact on the technologies that are available for use in LBS applications.

Location Technologies: Advantages and Disadvantages

All of the location sources available today (and in the immediate future) for LBS applications, are based either on mobile telephone or satellite positioning technologies. And in some cases they are a "hybrid" combining both types of technology.

At the simplest level, every mobile telephone knows which cell it is "talking to". In many countries the name of the cell is even displayed on your phone. And in urban areas, this information may be enough to identify your location to within 500m. But in suburban and rural areas, the cell ID may only determine your location to a few kilometres, while the worst-case in rural areas is up to 20km here in the UK. You may have noticed that many cell tower masts have several vertical antenna stips mounted around the mast. These can be used to determine which "sector" of the cell your phone is communicating with, which can cut down your location to maybe 100m in urban areas. But clearly Cell ID is insufficient to meet the E-911 legislation. Even with 2.5G and 3G networks that are being deployed over the next few years, Cell ID will only meet legislative requirements in the most densely populated areas (and that's precisely where more accuracy tends to be needed to locate someone in an emergency).

But as many of you will have noticed, the cell displayed by your phone changes frequently, as your phone "roams" around, seeking the best signal. Even if you're not physically roaming (moving), your phone is generally communicating with several cells at once. This fact is being leveraged by companies seeking to use the strength and speed of radio signals travelling between your phone and these cells to further refine your location. By measuring the speed of signals between the phone and each cell, techniques such as E-OTD can be used to pin the phone's position down to around 50m. This technology is still evolving, and with new networks being designed, may well improve further. An advantage of this approach is that it requires little input from the phone itself, but it ***does*** require a non-trivial enhancement to each cell tower. And the network operators are reluctant to shoulder this cost all by themselves. Plus there is a privacy concern: if the network itself computes your position, it can do this all of the time – not just when you're calling 911. In the U.S., particularly, there is fear that "Big Brother" (in the form of the Federal Government) may track people at all times, using signals from their phones. So even though this technology is a reasonably cost-effective way to comply with E-911 legislation, it faces hurdles to gain acceptance from users.

Looking away from mobile phone technology for a moment, an alternative solution to the E-911 problem is to use satellite-based positioning technologies. The Global Positioning System (GPS) has long been a valuable tool for positioning, and even the least expensive GPS receivers achieve accuracy of 10-15m, which is well within the E-911 requirements. Plus some of the differential and kinematic positioning augmentations to GPS allow positioning at the sub-metre and centimetre levels. So GPS can comply with the E-911 requirements, and can offer high levels of position accuracy for a wide range of LBS applications. But GPS suffers from a weakness that severely impacts its use as an E-911 solution: it works only "outdoors".

So many telecoms companies are looking at combining mobile phone and satellite technologies to create "the perfect solution" for E-911. Since the mid 1990s (and prior to the E-911 legislation), positioning companies were trying to make GPS work in more hostile environments, particularly in high-rise cities. So they started using mobile phone signals to augment or assist GPS. Hence the terms "A-GPS" (Assisted GPS) and "WAG" (Wireless Assisted GPS). But since the E-911 legislation, most of these companies have turned themselves upside down as they're now trying to use GPS to assist mobile phones in their bid to comply with E-911. An A-GPS device uses signals from ground-based telecommunication cells and space-based satellites together to obtain a position that's as accurate as autonomous GPS, but is also available in environments where GPS doesn't work by itself (in buildings, tunnels, etc).

Returning to the location-continuum, it's relatively easy to plot the sections addressed by each of the technologies discussed. And it's clear that while mobile telephones can address a large chunk of this continuum, at the high-precision end where location is required to a few metres or better, GPS is the only technology that reliably provides this degree of accuracy today.

Professional and Consumer LBS Applications

There would have to be few souls on this planet who have not heard about Location-Based Services (LBS), given the hype that surrounds this market and the beleaguered telecomms companies who are praying that LBS will help them recoup their vast 3G investments. But relatively few analyses of LBS in the public press tend to go far beyond consumer-level applications such as those listed below:

- Where is the nearest Big Mac?
- What's the fastest way to the Autobahn?
- Where in my vicinity is the least expensive diesel?

While these applications, and others like them, will likely dominate the volume of LBS data traffic, they can all be considered as relatively "Low-Value" services. In most cases a user won't care if one McDonalds "restaurant" is in fact a few meters further away than another. Or if there are two fuel stations with slightly different diesel prices. Or if the map or data content served up to them isn't 100% up-to-date.

What these "Low-Value" services provide is essentially a window into data that's either free or easily accessible in the public domain. As a consequence, it is still unclear how LBS providers can squeeze profitable revenue streams from the users of these services. Practically every LBS application that has received press coverage in the past year is already available in some shape or form to office-bound internet users. More critically, in almost every case the information is ***free*** (or nearly free).

But away from the hustle and bustle of consumer LBS there's a whole range of "High-Value" professional applications, where some element of the LBS is ascribed significant value by the potential user base. Examples include:

- "Call Before You Dig" services, where a workman can stand on the edge of the road and request information on the services (gas lines, water pipes, fibre-optic cables, etc) that lie directly beneath him. Today, many contractors operate on the "dig and see what happens" principle, which can be hideously expensive for both the contractor and the owner of the buried assets (not to mention their "downstream customers whose TV coverage or water supply may be disrupted).
- "Quote a New Connection" services, where a utility salesperson gives an on-the-spot customer quotation, based on data about the underlying utility network, the customer's premises in relation to

this network and their preferred connection point(s). Today, most utility quotations require a sales person to return to their office after a site visit, consult their engineering teams (who may also have to visit the customer's site), and deliver a quotation after several elapsed days or weeks.

- "Insurance assessment", where an assessor may need to accurately measure the distance between an asset and an identified risk, or between the location of a claim and the area of coverage.

In each of these cases, one or more of the following has extremely high value:

- The location
- The underlying data set
- The data being collected, validated or updated by the field worker
- The analysis that can be performed based on the location, the data and other inputs

There are many "Professional" Location-Based Services, and while these may represent a small proportion of the total LBS user base (in terms of the telecommunications bandwidth they require), there are numerous opportunities for organizations to create solutions using high-quality positioning, high-quality data or high-quality data handling software.

It's clear from the list of examples above that most of these "Professional" LBS applications require location to be known more precisely than mobile phone technologies can achieve. In most cases these applications will therefore be serviced by GPS satellite positioning technologies instead.

GPS for Professional LBS Applications

The Global Positioning System (GPS) has long been a valuable tool for positioning, and has been employed in GIS field applications (predominantly data collection) for over a decade. In contrast to mobile phone technologies, even the least expensive GPS receiver delivers 10-15m accuracy in most situations, and real-time accuracy of better than 1m is available for a modest cost in most parts of the world. Of course GPS can deliver far higher accuracy, in exchange for larger investments and denser infrastructure, and many High-Value LBS applications will require location at the decimetre- or even centimetre-level.

GPS-based solutions can therefore provide a range of accuracies, at varying levels of cost and convenience. But many of the more accurate GPS systems on the market are unsuitable for LBS applications, either because of the way they're packaged or because of the way the user interacts with them.

So GPS technology has needed to evolve – rapidly – to address the needs of high-value LBS and Mobile GIS applications. The following sections highlight several aspects of this evolutionary process:

Ergonomics

Just a couple of years ago, accurate GPS systems required the user to wear a backpack or carry a range-pole. And clearly the majority of potential LBS users would be reluctant to add a "Ghost-busters" backpack to their everyday working wardrobe. But GPS systems offering a couple of meters' accuracy are now "wearable", and can be operated in a trouser or coat pocket, making them far more suitable for broad LBS applications. We expect to see more of this trend, from backpacks and cables to "wearable" or hand-held solutions which interact wirelessly with their environment.

Accuracy

Only last year, decimetre-level accuracy required professional "surveying" skills (and budgets), but with the creation of networked nation-wide infrastructure in many countries, high-precision GPS is now more economical, more available, more reliable and more convenient. Professional surveyors are no longer required to achieve high accuracy results with GPS.

And more recently, the first hand-held systems achieving sub-metre accuracy have been launched. So finally we have the kind of packaging that's needed for professional LBS applications, coupled with the kind of accuracy that these applications require.

Integration

And along with greater convenience and flexibility, GPS sensors are now more easily embedded in regular field applications. Increasingly, GPS systems are moving from closed proprietary architectures to open architectures based on Palm OS and Windows CE, permitting custom LBS applications to take advantage of the accuracy and flexibility offered by GPS. So Mobile GIS field software such as ESRI's ArcPad or IntelliWhere's OnDemand can now tap easily into a variety of GPS sensors from a variety of manufacturers to deliver a whole range of capabilities within a familiar software environment.

New Field Platforms

Even though professional LBS applications tend to require location accuracy that can't be delivered by consumer-level devices, these applications can still benefit from advances in consumer electronics. The wide range of field computers available now is finally making it cost-effective to consider deploying hundreds or thousands of computers into the field. And many of the capabilities of these consumer electronic platforms, like digital cameras, wireless communications and multimedia input can be valuable additions to a professional LBS solution.

But it's important to appreciate that these devices are targeted at a broad market where cost is a critical factor. No consumer PDAs are truly watertight, and most don't survive even a drop onto carpet, let alone onto tarmac. So organizations planning field deployment need to trade off individual unit costs against longer-term cost of ownership and suitability to purpose. Clearly a warehousing application will have lower environmental requirements than a fire-fighting or forestry application where field computers need to survive in hostile conditions year in and year out.

Wireless Links to GIS

And lastly, a trend that has nothing to do with GPS is the whole way of handling Mobile GIS data.

In the past, this meant loading (a portion of) the GIS database onto a field computer and carrying this, together with full-blown GIS software, into the field. This meant that the field platform had to be a "fat" client, with lots of storage, lots of intelligence and lots of computing power. Which added up to lots of cost (and weight and power consumption, sadly). Plus the more insidious costs and problems relating to the management of GIS data that had been replicated onto lots of field computers that only return to the office periodically.

The modern approach, driven partly by LBS requirements, is to carry only a minimal (and preferably static) fragment of the GIS database into the field, and then to interact with the GIS wirelessly. This approach offers many benefits, including:

- A potentially very thin client, which reduces the capital cost of each field system and trades off storage and CPU power for telecoms bandwidth
- Reduced data replication, which assists with data integrity and management. Whenever a field worker looks at a data element, they see precisely what's in the database at that moment. So decisions are always made on the basis of up-to-date information.
- Shortened "transaction" times, where data that's modified is transmitted out to the field worker, edited and returned to the database within a few seconds or minutes, rather than residing on the field worker's computer for days or weeks.

Importantly, what's making this possible is the emergence of industry standards for sharing GIS data wirelessly. Such standards include IMS/WMS, which are open, plus a raft of semi-open and proprietary standards. These are allowing the manufacturers of server-side and field-side equipment to work together to create complete solutions addressing the needs of the whole enterprise.

Conclusion

The broader market for Consumer LBS will generally be satisfied with the positional accuracy that can be provided by every mobile telephone ("tomorrow", if not today). And while some mobile phones may actually incorporate GPS, this application area will undoubtedly remain the property of Messers Nokia, Ericsson, Motorola, et. al.

But for many Professional LBS applications, high-quality position is going to be a necessary element, and GPS is by far the most cost-effective and practical source of location for this class of LBS application.

And as outlined in this paper, GPS itself is evolving to fit the lifestyle of LBS clients, in physical terms (packaging), in accuracy, in flexibility and in its links back to the office.