Performance Implications of Wireless Location Technologies – The Effect on Location-based Service Revenue Growth

a report by

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For 10 years, the wireless industry has been talking about the exciting possibilities of location-based services (LBS) but, despite the introduction of several different types of technology, revenues from commercial LBS are less than expected.

It is believed that a key obstacle to the development of LBS is the fact that some of the location technologies that support these services have performance limitations that hinder their ability to effectively support some of the more demanding applications. As the requirements for LBS increase, the importance and precision of the location information escalate, a situation that is not ideal. A little-known network-based technology being used in the US to support the government's Emergency 911 mandate shows promise for effectively enabling LBS in the US and the rest of the world.

Performance Requirements of Key Applications

Some of the applications currently under discussion for commercial LBS are the following:

- information services – could provide the location of the nearest automated teller machine (ATM) or petrol station;
- navigation services – could provide street-by-street, turn-by-turn directions to a destination;
- field force automation/workforce management services – could manage the realtime allocation of jobs to engineers based on who is where and the progress of their current task;
- lone-worker tracking – could assist workers in high-risk locations, offering a 'panic button' and an immediate location fix if they get into trouble;
- demand-responsive transport/taxi dispatch services – could manage community transport and taxi fleets, allocating jobs by location, direction and speed of travel, and offering more accurate estimated arrival times to customers;
- child-tracking services – could provide the location of a child and/or alert when the child moves outside a predetermined area. The device being located could be a mobile phone, or a specialised data-only device that could be built into clothing or jewellery; and
- medical alert services – could give the location of patients who suddenly become ill. Using specialised cellular devices, it could be possible to transmit some basic medical data to a hospital or paramedics.

How good the location technology needs to be to make these applications commercially viable depends on the application. The two principle measurements of a location technology's performance are accuracy and yield. Accuracy refers to the radius in which a location technology can pinpoint the location of a mobile phone; yield refers to the location technology's ability to obtain a location fix, expressed as a percentage success rate. The performance requirements of applications are partially dependent on where the person or device to be located happens to be at the time.

Table 1 summarises the performance requirements of these applications, based on research that has been conducted among key application developers. The underlying location technology used to support these applications will impact revenues in the following three ways.

- The closer the technology comes to delivering optimum performance in each environment, the greater the revenues that will derive from the application.
- The more consistent the performance of the technology (in terms of both accuracy and yield), the greater the revenues it will support. This is especially true of corporate or personal safety applications.
- Technologies that support legacy subscribers allow services to be offered to the entire subscriber base as soon as they are launched.

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Technologies that require specialised handsets will have to wait for take-up of those handsets.

Unfortunately, no single technology is ideal for every application. However, there are significant differences between available technologies on these measures.

Technologies on Offer

Mobile operators can choose from a range of technologies to support LBS, as listed in *Table 2*.

Cell identification (Cell-ID) and Enhanced Cell-ID rely on information inherent to cellular networks about which sector of a given cell a phone is communicating with. With the aid of algorithms and mapping information, these technologies can hazard a guess at the location of the handset. Their accuracy, however, is inconsistent. In areas where base stations are densely packed (such as city centres), they can achieve an accuracy of 100 metres to 350 metres. In rural locations, accuracies are in the order of kilometres. Both technologies support legacy subscribers.

Uplink Time Difference of Arrival (U-TDOA), Enhanced Observed Time Difference (E-OTD) and Assisted Global Positioning System (A-GPS) all use triangulation to determine the position of the phone. In the cases of A-GPS and E-OTD, the phone is involved to some extent in the position-finding process.

A-GPS technology relies on positioning signals from Global Positioning System satellites. By calculating the time difference between the arrival of signals from different satellites, the phone can determine its location to within 10 metres under ideal conditions.

A-GPS consistency is not ideal in that it suffers performance degradation indoors and in urban canyons, because the satellite signals can be blocked by walls and ceilings. A-GPS does not support legacy terminals. It requires specialised handsets, which are considerably more expensive than standard models.

E-OTD operates on the same principles, but the positioning signals are received from base stations. In GSM™ networks, the timing of base transceiver station transmissions is measured at a location management unit associated with the base station. When a mobile is to be located, it makes relative timing measurements of up to eight base stations and transmits those measurements to the network, which approximates the location of the phone.

E-OTD can suffer degradation in accuracy in rural areas where there are few base stations in range. In tests conducted in the US, E-OTD appears to suffer from additional performance problems. The causes of these problems are currently unknown, but they may be associated with E-OTD's dependence on the mobile unit to do some of the work in the location-

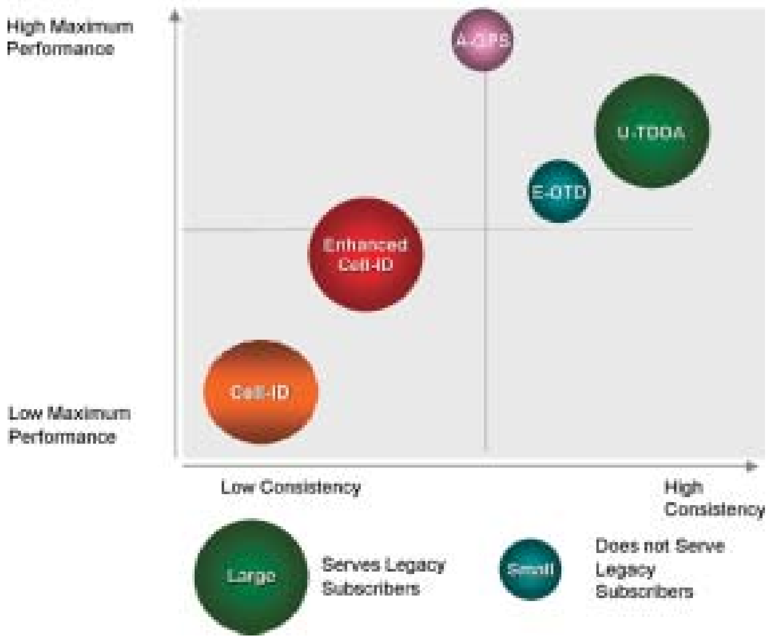
Table 1: Performance Requirements of Selected Location-based Applications

	Indoor		Urban		Suburban		Rural	
	Accuracy	Yield	Accuracy	Yield	Accuracy	Yield	Accuracy	Yield
Information services								
• Basic	50m–100m	80%	500m	80%	1,000m	80%	5,000m	80%
• Enhanced	20m–50m	90%	50m	90%	50m	90%	50m–100m	90%
Navigation	10m	95%	10m	99.9%	10m	99.9%	20m	99.9%
Field force automation/workforce management	50m	95%	50m	95%	50m	95%	100m	95%
Lone-worker tracking	50m	99.9%	50m	99.9%	50m	99.9%	100m	99.9%
Demand-responsive transport/taxi dispatch	n/a	n/a	50m	90%	50m	90%	50m	90%
Child tracking	50m	99.9%	50m	99.9%	50m–100m	99.9%	50m–100m	99.9%
Medical alert	50m	99.9%	50m	99.9%	50m–100m	99.9%	50m–100m	99.9%

Table 2

Abbreviation	Full Name	Urban Accuracy (metres)	Consistency of operation in urban/rural environments	Consistency of operation indoors/outdoors	Supports legacy terminals?
Cell-ID	Cell Identification	250	Poor	Excellent	Yes
Enhanced Cell-ID	Enhanced Cell Identification	100	Fair	Good	Yes
U-TDOA	Uplink Time Difference of Arrival	sub-50	Good	Excellent	Yes
E-OTD	Enhanced Observed Time Difference	Approaching 100	Fair	Good	No
A-GPS	Assisted Global Positioning System	100+ to 20	Good	Poor	No

Figure 1: Attributes of Location Technologies



Source: BWCS.

fixing process. Mobile phones have limited capability to 'listen' for signals and their internal clocks may also be affected by factors such as ambient temperature. E-OTD does not support legacy handsets; however, E-OTD-enabled handsets are comparable in price to conventional models.

U-TDOA network equipment at base station sites 'listens' for signals normally transmitted from the handset and, by measuring the time difference of arrival of these signals at different base station sites, the network computes the end-user's location. Like E-OTD, U-TDOA can suffer performance degradation in remote areas; however, since the handsets are not required to participate in the location-fixing process, U-TDOA does not suffer from any problems associated with handset performance. U-TDOA supports legacy handsets. The relative performance of these location technologies is summarised schematically in *Figure 1*.

Mapping Technologies to Application

The differences in capabilities of these technologies means that they vary widely in their suitability for different applications as *Table 3* shows. U-TDOA emerges as the best overall technology, being well suited to all applications except navigation.

LBS Revenues

The expected revenues from these applications and others were modelled to see how they would be affected by the performance, consistency and support for legacy subscribers offered by the key location technologies. The output of the model is given in *Table 4* for an operator with a 2.5G network and 10 million subscribers in the developed world.

It is believed that an operator that chooses U-TDOA as a single technology solution would have significantly higher location-based revenues over five years than one that chooses any other technology. Cell-ID would be the least favourable option because of its poor accuracy and consistency. A-GPS, despite its high accuracy, also fares badly because of its poor indoor performance and its inability to support legacy terminals.

U-TDOA also fares better as a single solution than dual-technology solutions such as E-OTD plus Cell-ID and A-GPS plus Cell-ID and is the least known of all the technology solutions. In the US, where the Federal Communications Commission (FCC) has mandated high accuracy capabilities on cellular networks, most operators chose A-GPS or E-OTD as their technology solutions.

In Europe, where there is no equivalent to the FCC mandate, Cell-ID is the technology of choice, because of its low cost. Most operators are considering upgrading to Enhanced Cell-ID in the future and beyond that there are no firm plans. European operators are firmly focused on making money from LBS, but equally focused on controlling

Table 3: Suitability of Location Technologies to Selected Applications

	Cell-ID		Enhanced Cell-ID		E-OTD		U-TDOA		A-GPS	
Basic information service	◑	●	●	●	●	●	●	●	◑	●
Enhanced information service	○	○	◑	○	◑	◑	●	●	◑	●
Navigation	○	○	○	○	○	○	○	○	◑	●
Field force automation/workforce management	○	○	◑	○	◑	◑	●	●	◑	●
Lone-worker tracking	○	○	○	○	◑	◑	●	●	◑	●
Demand-responsive transport/taxi dispatch	○	○	○	○	◑	◑	●	●	◑	●
Child tracking	○	○	○	○	◑	◑	●	●	◑	●
Medical alert	○	○	○	○	◑	◑	●	●	◑	●

● ● – Highly Suitable ◑ ◑ – Adequate ○ ○ – Unsuitable ◑ ● ○ – Indoor/Urban ◑ ● ○ – Suburban/Rural

Source: BWCS.

their capital expenditure budgets.

In the light of this analysis, it is believed that operators would do well to consider the merits of U-TDOA as a location technology solution.

Summary

Location-based applications have differing levels of optimum performance (in terms of accuracy and yield). These vary according to the nature of the application and the environment of the device to be located (i.e. indoor, urban, suburban and rural). The closer an underlying location technology comes to meeting these performance requirements consistently, the more revenues will be generated from location-based applications.

Location technologies differ in the accuracy and yield they offer and their consistency of performance across all environments. They also differ in their ability to support legacy subscribers. No single technology is ideal for all applications in all environments, but U-TDOA is the best single technology option, since it offers sub-50-metre accuracy in urban environments and high consistency and supports legacy terminals.

Table 4: LBS Revenue Model

	Sum of Five-year Revenues from LBS ($US m)				
Application	**Cell-ID**	**Enhanced Cell-ID**	**U-TDOA**	**E-OTD**	**A-GPS**
Information (basic and enhanced)	8.6	12.5	23.1	9.2	5.0
Navigation	0.0	0.0	0.0	0.0	8.3
Workforce Automation	8.6	11.0	20.7	16.3	4.3
Lone-worker tracking	0.0	0.4	3.5	2.7	0.8
Fleet management	3.1	4.6	8.5	6.5	2.1
Tracking children	2.3	5.5	19.2	14.8	4.3
Medical alert	0.1	1.6	12.8	9.5	2.6
Other applications	9.6	15.9	37.6	29.2	8.7
Total:	**32.3**	**51.5**	**125.4**	**88.2**	**36.1**

U-TDOA would deliver the highest LBS revenues over five years of any technology solution for a typical cellular operator. It also outperforms hybrid solutions of Cell-ID and E-OTD and Cell-ID and A-GPS on this measure; however, it is the least known of all location technologies in both the US and Europe. Re-evaluation of the merits of U-TDOA is recommended in the light of these findings. ■

A full copy of this study, including appendices, is available by request from info@bwcs.com