

## Playing Nice... LBS and Hybrid Location Technologies

During his keynote speech at Apple's WWDC in June 2008, Steve Jobs foreshadowed two industry trends with the announcement of the iPhone 3G: *"Location services is going to be a really big deal on the iPhone... it's going to explode. We get location data from cell towers, from Wi-Fi, and now we also get it from GPS."* The first trend is obvious: location services have indeed become a really big deal (with more than 1,000 location-enabled applications) on the iPhone and for the rest of the mobile industry. Google's recent announcement of free turn-by-turn navigation for mobile devices will only accelerate this trend. The second, less visible, trend is the blending of multiple (hybrid) location technologies in mobile devices. This article explains the linkage between the two trends and how hybrid location technology enables a better user experience of Location-based Services (LBS).

Jobs explicitly mentioned three location technologies: Cell Tower Positioning (Cell-ID), Wi-Fi Positioning, and the Global Positioning System (GPS). Why three? Because each technology, in isolation, can not meet consumer expectations: *quick and accurate determination of user location anywhere in the world*. LBS are useful only when users' locations are known; it takes a blend of several technologies to reliably achieve this, adding to device cost and complexity.

Not all devices use the same mix of location technologies, but the three used in the iPhone are currently the most common. Others, such as the GLONASS satellite system, are likely to be joining them soon. TV Signals, Bluetooth, Radio Frequency Identification (RFIDs) and a variety of on-board sensors can also be used. Let's go deeper into the pros and cons of each common technology.

### GPS

GPS is the leading location technology, since it enables the most accurate position calculation. On mobile devices, assistance data can be provided over the cellular network (A-GPS) to make the position calculation faster and more reliable. On networks that support A-GPS, user location can take less than 10 seconds, with accuracies approaching 5 meters. Although most smartphones today already have A-GPS capability, its usefulness starts to break down as the sky becomes more obstructed - in urban streets and especially indoors. This is why GPS technology by itself is insufficient.

### GPS + GLONASS

GLONASS is a navigation satellite system, similar in concept to GPS, owned by Russia. It is set to make a major impact on mobile device positioning in 2010 and beyond, following recent investment in the system and the opening of full civilian access to its signals. The addition of GLONASS positioning can help in difficult environments such as urban streets, where much of the sky is obstructed and reflections from tall buildings can confuse satellite receivers. At least three satellite signals are needed to calculate the position of a device, so having *more* satellites available in the sky increases the chances of being able to receive more “line-of-sight” signals. Devices that use both GPS and GLONASS can take advantage of almost twice the number of usable satellites in the sky compared to GPS alone, giving much better location performance in challenging environments. Assistance data sent over the cellular network (A-GLONASS) will further improve the speed and reliability of position fixes. Like GPS, GLONASS also performs poorly indoors, so the combination of GPS and GLONASS technologies is still not enough.

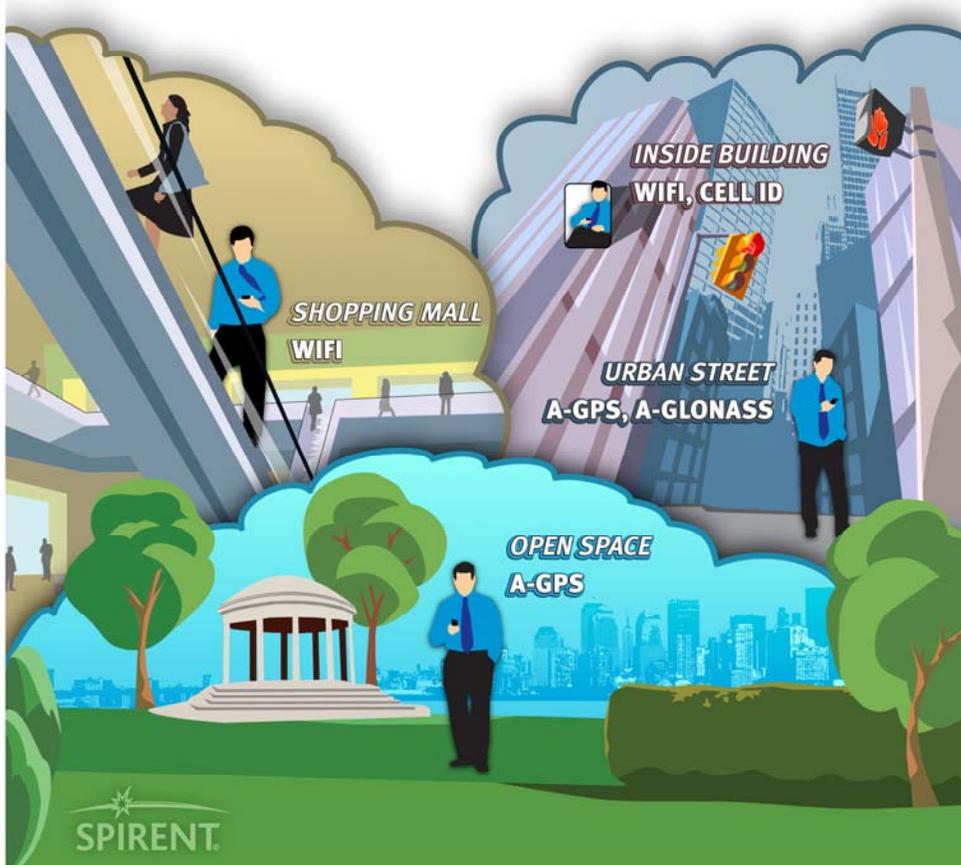
### **Wi-Fi**

Wi-Fi access points are becoming increasingly dense in the areas in which many of us live and work: urban and indoor environments. Nearly all smartphones today support Wi-Fi and the technology can be used for positioning, using comprehensive databases of access point locations. In many locations multiple Wi-Fi signals are present, so triangulation or pattern-matching algorithms can be used to dramatically enhance location performance, to the point that indoor navigation applications in environments such as shopping malls are now possible. In the right environments, position fixes accurate to 10-20 meters are possible in a couple of seconds. The primary downside of this technology is that Wi-Fi access points may be dense in urban areas but are far less numerous in suburban or rural areas. So this technology is also insufficient for use by itself.

### **Cellular Network**

Cellular Network positioning is often the “fallback” technology used when GPS, GLONASS and Wi-Fi signals are unavailable. Cell Identification (Cell-ID), the simplest location technology, locates a user based on the cell they are using, though the accuracy of this technique varies widely. Cellular network triangulation, either signal strength-based or time-based, can be used to improve accuracy and time-based methods such as Time Difference of Arrival are common. Compared to A-GPS/A-GLONASS, cellular network positioning is generally faster (~5 seconds), but it is less accurate (50 meters to several kilometers). This technology only fails completely when no cellular signals are available.

The diagram and table summarize hybrid location technologies' roles:



	Ideal Performance	Pros	Cons
A-GPS	5 - 20m Accuracy 10 - 20s TTFF*	High Accuracy Open Spaces	Urban Streets Indoors
A-GPS + A-GLONASS	5 - 20m Accuracy 10 - 20s TTFF*	High Accuracy Open Spaces Urban Streets	Indoors
WiFi	10 - 50m Accuracy 1 - 4s TTFF*	High Accuracy Indoors Urban Streets	Open Spaces
Cellular Network	50 - >1000m Accuracy 2 - 6s TTFF*	Works everywhere that cellular coverage is available	Poor Accuracy

\*TTFF (Time to First Fix)

### Challenges of Hybrid Location Technology

Every great idea comes with a tradeoff. In this case, hybrid location technology introduces additional costs and complexity. While the cost increases can generally be justified by the improvement in performance, complexity increases are more difficult to quantify. Higher complexity can lead to more unforeseen issues, for example when technologies interact with each other in unexpected ways. If location technologies do not play nicely together, performance gains are negated. Thorough testing of hybrid location technology is therefore essential to validate theoretical performance gains, otherwise there is no way to know whether the additional investment has paid off.

### Summary

This article has shown why hybrid location technology is a prerequisite for widespread LBS usage. The number of potential applications enabled by *quick and accurate determination of location anywhere in the world* is staggering and the whole world will benefit. It is therefore very important to ensure that location technologies play nicely together.