White Paper

Evaluating OTDOA Technology in Support of PS-LTE

Introduction

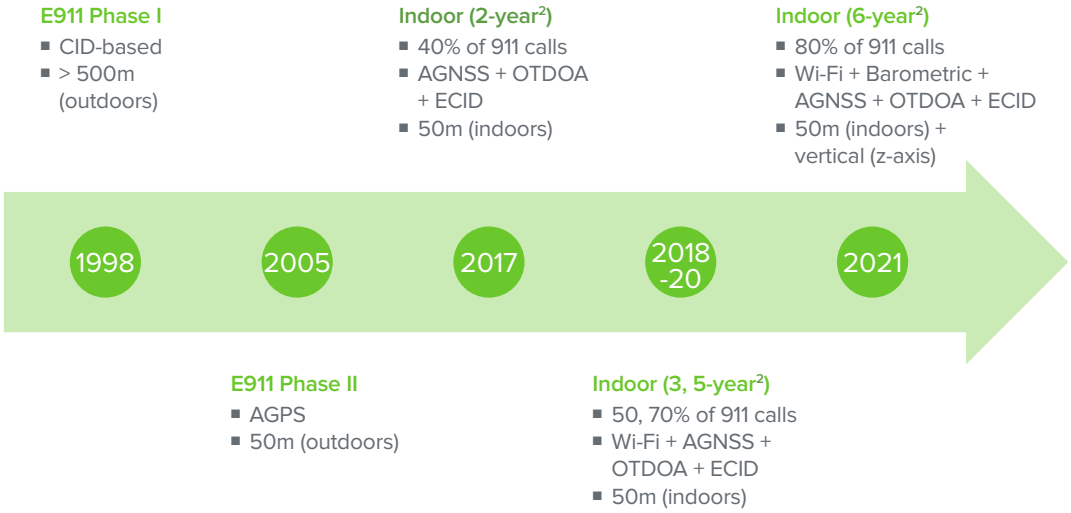
As mobile device usage becomes more and more ubiquitous, there is an increasing need for location accuracy, especially in the event of an emergency. In recent years, the United States' Federal Communications Commission (FCC) has imposed stringent location requirements for indoor environments, making it crucial for carriers to understand how positioning technologies, such as Wi-Fi and OTDOA, can address the enhanced FCC regulations and be prepared to meet the upcoming deadlines.

Drawing from the experience gained with E911 and the incorporation of LTE, new Public Safety over LTE (PS-LTE) networks are being created that will take advantage of the established positioning techniques to better serve emergency personnel communications and provide faster and more accurate response in times of crisis.

The FCC estimates that roughly 80% of 911 calls are placed from wireless phones[1], and a majority of these originate indoors. Obtaining a position fix indoors with conventional technologies such as A-GNSS is difficult due to multipath reflections and multiple sources of interference and obscuration, which can increase error margins to literally hundreds of meters. In dense urban areas with closely-situated multi-story buildings, just a few feet can make a huge difference in emergency personnel communications and locating a 911 caller in need.

To improve positioning accuracy in these scenarios and meet the upcoming FCC mandates (timeline shown in Figure 1), the Public Safety industry is taking advantage of key capabilities within existing LTE and Wi-Fi networks. The incorporation of LTE and Wi-Fi positioning technologies brings a promise of improved location accuracy due to their integration using hybrid techniques. Spirent is working closely with industry leaders to validate how these technologies can help address the indoor positioning challenge.

[1] 2016 National 911 Progress Report, issued Dec 2016



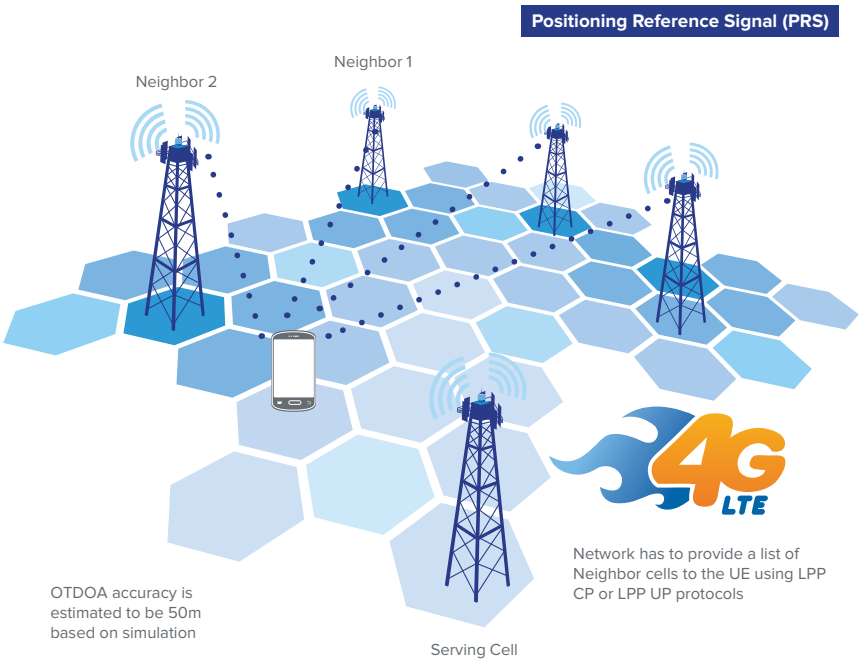
FCC mandate timeline for E911 location accuracy requirements

Positioning Technology Overview

The most widely-used high-accuracy location technique is Assisted GNSS (A-GNSS), which uses ranging signals from Global Navigation Satellite Systems (GNSS) such as the North American Global Positioning System (GPS) and Russian Globalnaya Navigazionnaya Sputnikovaya Sistema (GLONASS), along with data from the network, to obtain a location fix. A-GNSS provides excellent performance in environments with a clear view of the sky, but performance is poor in dense urban environments and indoors, where detection of satellite signals is limited. In these cases, alternate "hybrid" positioning technologies are used to either replace or augment satellite positioning. In LTE, current standards support Enhanced Cell ID (ECID) and Observed Time Difference of Arrival (OTDOA) to augment A-GNSS for device-based positioning techniques. This paper focuses on OTDOA and its ability to provide increased accuracy of location information for indoor scenarios—either individually or combined with A-GNSS. Later, it also touches upon Wi-Fi, the next piece of the puzzle.

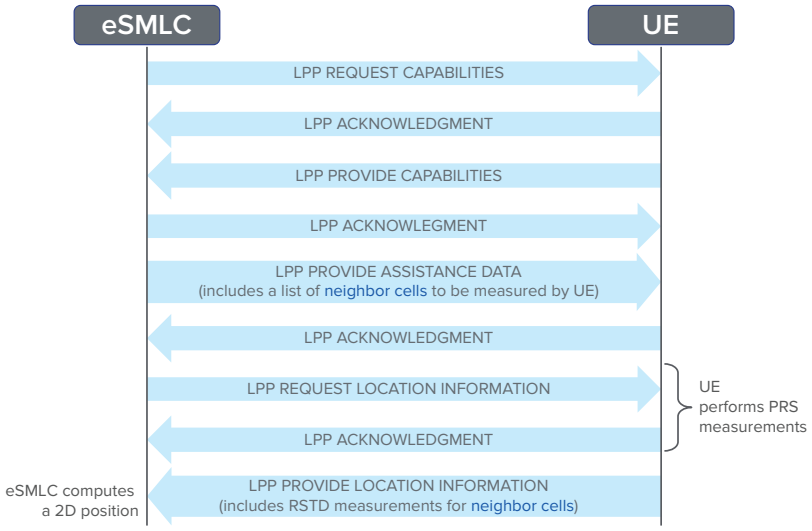
The basic OTDOA principle involves the UE measuring time differences in downlink signals from a number of eNodeBs. These measurements are sent back to the network. Using the known position of the eNodeBs and these time differences, it is then possible to calculate the position of the UE. In LTE, a cell-specific reference signal has been defined for positioning, called the Positioning Reference Signal (PRS). The measured time difference of arrival of the PRS from a serving cell and neighboring cells is known as the Reference Signal Time Difference (RSTD). Using the RSTD measurements, the known position of the eNodeB transmit antennas and the transmission timing of each cell, the network can calculate the UE's position.

[2] Timeline to adhere to FCC mandate given in FY2015



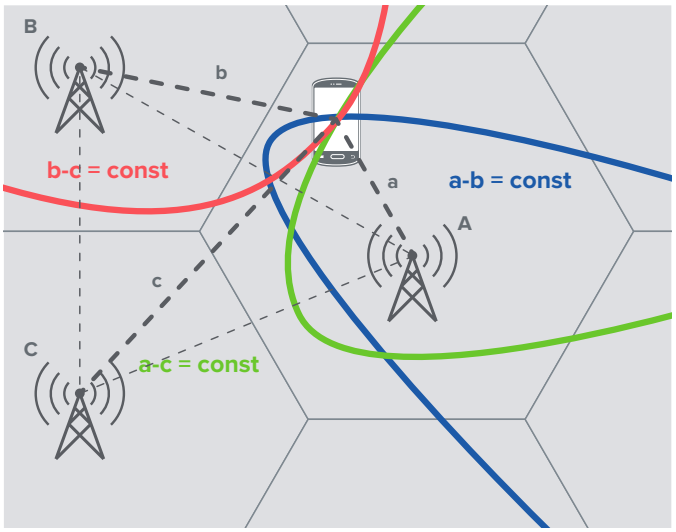
In OTDOA positioning, the User Equipment (UE) receives periodic Positioning Reference Signal (PRS) transmissions from the LTE eNodeB as well as information from the Evolved Serving Mobile Location Center (eSMLC) about the PRS configurations of the neighbor cells based on its serving cell.

Figure 1.
PRS Transmission between UE and Cells



The UE uses the information in the assistance data to "hear" the PRS transmitted by neighbor cells and calculates the Received Signal Time Difference (RSTD) from a reference cell.

Figure 2.
LTE Positioning Call Flow Process



Once RSTD measurements are received back from the UE, the eSMLC uses the reported measurements to compute a latitude and longitude for the reporting UE.

Figure 3.
Device Position is derived by the intersection of three hyperbolas (A-B, A-C, B-C)

OTDOA Challenges

OTDOA positioning requires comprehensive testing to ensure its ability to meet the evolving FCC regulations for E911 and to fully validate compliance with PS-LTE network performance requirements. Spirent is currently working with leading industry players in evaluating OTDOA positioning technology, and this extensive assessment has revealed complex interoperability issues and critical aspects that must be addressed in utilizing OTDOA positioning technology for improved location accuracy indoors. Although OTDOA is a critical component, it is the combination of multiple positioning technologies that will ultimately be required to meet the location requirements of the mobile user and the FCC E911 mandates. The following list represents Spirent's key learnings and challenges for OTDOA deployment and will expand as its investigation into LTE positioning technologies and hybrid location continues.

Accurate neighbor cell information needs to be maintained by the network

Cellular network deployments undergo periodic optimization, e.g., new cell sites may be introduced, some cell sites may be turned off, etc. Operators must maintain periodic optimization of cellular networks in a timely and accurate manner.

Operators must maintain periodic optimization of cellular networks in a timely and accurate manner.

The eSMLC needs to be up-to-date on the network deployment with accurate neighbor cell information

Network optimization changes require the eSMLC cell site database to be kept in synchronization with the actual cell site deployment. If the neighbor cell information provided by the eSMLC is out of sync, the device will either not be able to measure a few cells correctly or, worst case, will not be able to make any PRS measurements. If the eSMLC has outdated cell information, the UE's location cannot be determined.

If the eSMLC has outdated cell information, the UE's location cannot be determined.

Network operators must identify the best PRS configurations for the cells in a given deployment area

PRS transmission requires LTE bandwidth to be utilized. If the PRS periodicity is high, it will impact the bandwidth usage for all the other UEs on the network. If the PRS periodicity is low, the UE performing PRS measurements will not be able to make accurate measurements. The network topology and the Radio Frequency (RF) environment have an impact on the PRS configurations used by the network to enable OTDOA positioning.

The network topology and the Radio Frequency (RF) environment have an impact on the PRS configurations used by the network to enable OTDOA positioning.

OTDOA performance and measurement can vary between LTE Downlink channels

Network operators utilize multiple LTE Bands for their deployment. The same UE can have variance in determining the PRS measurements on different LTE downlink channels due to the radio frequencies being used. Network operators not only have to plan the PRS configurations well but also need to choose the appropriate LTE Downlink channels for neighbor cells.

Network operators not only have to plan the PRS configurations well but also need to choose the appropriate LTE Downlink channels for neighbor cells.

RF propagation unpredictability can affect PRS transmission

RF propagation varies across any deployment area, which makes it challenging to identify the perfect OTDOA PRS configurations for any given set of RF propagation conditions. Network operators must understand typical fading of the LTE signal in a given deployment area.

Carriers must understand typical fading of the LTE signal in a given deployment area.

OTDOA positioning is dependent on network infrastructure vendors

The OTDOA position calculation algorithms implemented by one vendor may be different from another vendor and operators need to ensure consistency between these deployments for E911 positioning performance in all environments. Operators may use different vendors in different geographical regions and thus the positioning performance of devices needs to be evaluated in all regions.

Operators may use different vendors in different geographical regions and thus the positioning performance of devices needs to be evaluated in all regions.

Serving and neighbor cells can operate in different LTE bands

UEs will be required to tune to different LTE bands for an OTDOA positioning attempt if the neighbor cell list consists of cells that are on different LTE frequency channels. In order to perform RSTD measurements on different frequencies, the device will need to tune away from its serving frequency. The UE needs to perform Inter-Frequency PRS measurements in areas where neighbor cells are operating in different LTE bands.

The UE needs to perform Inter-Frequency PRS measurements in areas where neighbor cells are operating in different LTE bands.

Added challenges of Carrier Aggregation

In a similar way to Inter-frequency challenges, Carrier Aggregation further complicates the UE's ability to make PRS measurements. In areas where Carrier Aggregation will be deployed, the UE will need to be able to perform PRS measurements for cells with and without carrier aggregation capabilities.

In areas where Carrier Aggregation will be deployed, the UE will need to be able to perform PRS measurements for cells with and without carrier aggregation capabilities.

About Spirent Communications

Spirent Communications (LSE: SPT) is a global leader with deep expertise and decades of experience in testing, assurance, analytics and security, serving developers, service providers, and enterprise networks.

We help bring clarity to increasingly complex technological and business challenges.

Spirent's customers have made a promise to their customers to deliver superior performance. Spirent assures that those promises are fulfilled.

For more information, visit: www.spirent.com

The Next Step: Wi-Fi Positioning Integration

In line with the next FCC mandate, Wi-Fi positioning brings a new potential for even greater indoor location accuracy, especially where the LTE signal is weak. The proliferation of public and private Wi-Fi access points (APs) provides an abundance of equipment to take advantage of this positioning capability. Coupled with the fact that almost all new devices are equipped with Wi-Fi, this is an inexpensive and fast-to-market addition to supplementing location-based services.

There are several methods used for localization via Wi-Fi access points: Received Signal Strength Indication (RSSI), fingerprinting, Angle of Arrival (AoA), and Time of Flight (ToF). Even the least accurate of these methods, RSSI, can pinpoint a location as closely as 2-4m, which is a marked improvement over the 50m achievable with OTDOA.

However, there are still some challenges to be addressed with Wi-Fi integration:

- Since the primary use case for Wi-Fi is connectivity and internet access, it's not geared for scanning multiple access points for triangulation, which is critical for positioning.
- Searching and scanning is not defined, so different chipsets can have very different results. In an extreme case, if a device attaches to an AP, it may not perform any additional scanning because that will decrease throughput, which is in conflict to its prime directive.
- There are currently no standard test plans to address Wi-Fi location performance.

Unique PS-LTE Location Challenges

The PS-LTE network will provide critical services that must work from day one and continue to work in conditions where typical LTE communications may not. PS-LTE deployment is complex and brings additional challenges, such as call priortization, faster call setup times and shorter Time to First Fix (TTFF). Accuracy and speed are of paramount importance, so there may be a need to add even more technologies, such as integration of multiple GNSS frequencies, to achieve the positioning certainty required to support emergency personnel in the race against the clock.

As the recognized industry leader in location technology testing, Spirent is committed to identifying and developing test capabilities that enable PS-LTE operators to effectively address FCC indoor requirements and deliver optimal location performance, in any scenario.

spirent™ Promise. Assured.

Contact Us

For more information, call your Spirent sales representative or visit us on the web at www.spirent.com/ContactSpirent.

www.spirent.com

Americas 1-800-SPIRENT
+1-800-774-7368 | sales@spirent.com

US Government & Defense
info@spirentfederal.com | spirentfederal.com

Europe and the Middle East
+44 (0) 1293 767979 | emeainfo@spirent.com

Asia and the Pacific
+86-10-8518-2539 | salesasia@spirent.com

Rev B | 08/18