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Delivering Location in LTE Networks

Inside:

Executive Summary

Location Based Services (LBS) have been around in the market for many years. According to Juniper Research, revenues from mobile location based services are expected to grow to more than $12.7 billion by 2014. Further, with the mobile broadband demand picking up, 4G deployments are expected to increase. Long Term Evolution (LTE) has become one of the preferred 4G technologies. In order to monetize LBS and improve ROI on LTE deployment, vendors and carriers need to support LBS in LTE networks as well.

This paper evaluates available technical user plane (SUPL 2.0 - OMA) and control plane (3GPP) options to enable location determination in a LTE network. With this paper, carriers, infrastructure vendors, and handset vendors will find an overview of possible solution options to realize the revenue potential of LBS services. In addition, this paper provides a comparison of possible approaches and includes an analysis of how common challenges may be addressed.

Operators can utilize both the solutions options to improve the ROI of LTE deployment and address cost effective migration from 3G to 4G location solutions. In certain situations, SUPL 2.0 provides certain advantages over a control plane solution, which can also be leveraged. Further, handset vendors can monetize on LBS and gain a competitive advantage by deploying a SUPL 2.0 AGNSS based location solution.

Introduction

Location Based Services (LBS) have been present in market for many years. According to Juniper Research, revenues from mobile location based services could reach more than $12.7 billion by 2014[1]. The increase in revenue is driven by the rapid evolution of mobile phones, the surge in application storefront releases, deployments of higher-capacity network infrastructure, and recent developments in positioning technologies.

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On the 4G technology front, with the increasing need for mobile broadband, LTE is one of the major 4G technologies which not only has market potential, but is expected to increase in deployment across carriers. Already, many Tier 1 U.S. cellular operators have rolled out LTE network services. Gartner predicts that by 2015, LTE revenue will comprise of at least 4% of all mobile service revenue.[2]

Challenges to be addressed by operators in LTE deployment

- Identifying revenue sources which can improve the ROI considering the cost and complexity involved[2] in LTE deployment
- Leveraging the existing 3G location infrastructure in order to enable location services on 4G networks

Location services help the above challenges by enabling new services in the LTE network. These services enable operators, network infrastructure vendors, and handset vendors to benefit from new revenue streams, potentially giving them a competitive advantage. In addition, these services can help operators by increasing the ROI for LTE deployment.

Location services can help operators increase ROI for LTE deployment.

How this paper can help operators, infrastructure vendors and handset vendors

- Presents an overview of available technical solution options to enable location determination in a LTE network.
- Discusses various solutions to solve specific challenges

Overview of Solution Options

Traditionally, there have been two approaches to support position determination – control plane and user plane. LTE networks support both solution types through specifications from Open Mobile Alliance (OMA) and 3GPP. The following sections discuss the details of both solutions for location determination.

User Plane Solution

OMA has developed Secured User Place Location (SUPL) specification which supports user plane location determination for LTE networks. More specifically, SUPL 2.0 has added support for different network technologies like LTE, WiMax, etc.

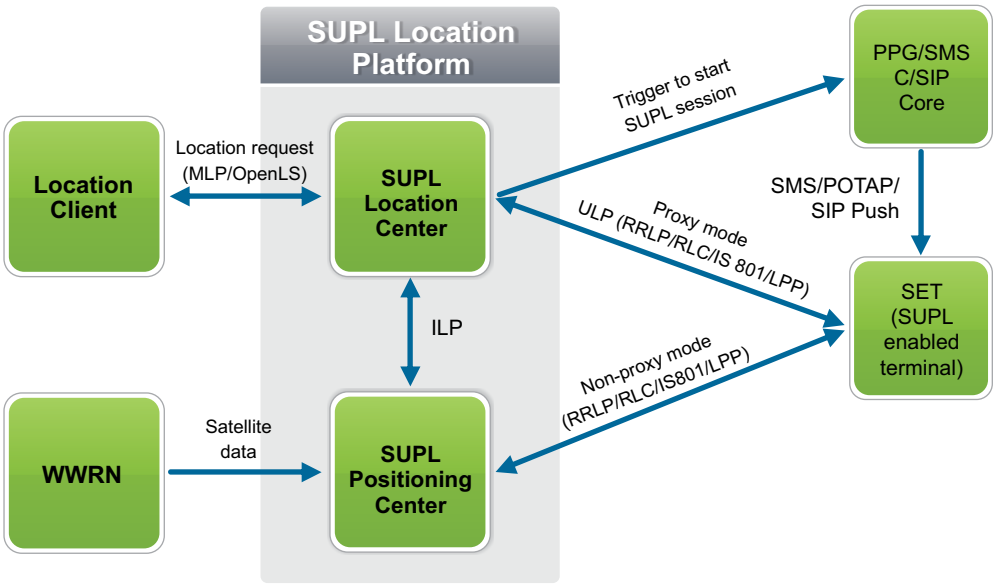

Figure 1: SUPL Architecture

SUPL 2.0 Solution Overview

SUPL solution is based on internet protocol communication between different entities involved in location determination and delivery. This solution supports various positioning technologies and network types. Figure 1 above highlights the important elements involved in location determination:

SUPL Network Elements

SUPL Enabled Terminal (SET): A device containing the SUPL Client/Agent. This device can initiate positioning requests by sending a message to the SLC or can help in the positioning process for network initiated requests.

SUPL Location Center (SLC): Receives location request from network client or hand set (SET). The SUPL Location center supports various features and functions defined as part of SUPL 2.0 specification such as event and area triggers.

SUPL Positioning Center (SPC): SPC is involved in positioning computation along with SUPL enabled handset (SET). SLC participates in positioning computation call flows between SPC and SET depending on whether SLC is in proxy mode. SPC is also enabled to work with WWRN elements to do AGPS based position determination.

SUPL Interfaces

SUPL specification defines interfaces between different elements for communication.

User Plane Location Protocol (ULP): Covers interactions between the SLC, SPC and SET. This protocol is encoded in ASN.1 and communicates the message content enabling different elements to exchange information. In addition, it supports the initial messages that start the positioning session, exchange positioning data, and terminate the positioning session. Further, ULP contains message specifications to support services such as area event trigger services, periodic services, etc.

LTE Positioning Protocol (LPP): An interface that is used between the SPC and the target device (SET) in order to obtain location related measurements, location estimates, or to transfer assistance data for position computation.

SUPL Features and Benefits

SUPL supports various features as listed below:

Feature	Description	Benefit
Periodic Position Determination	Allows location determination between SET and SPC in a periodic fashion supported by both network and mobile initiated requests.	Helps in various LBS services such as navigation, tracking etc.
Triggered Position Determination	Transmits event and area based triggers. Position calculation takes place when a registered event has occurred or upon entering/leaving an identified area.	Helps in various LBS services such as geo-fencing.
Emergency Positioning Procedures	Requests location for emergency services.	Eliminates the need for an additional network to provide emergency services, however, this requires a network based position determination.
Positioning Technology Support	Supports various positioning technologies: A-GPS SET Assisted/Based only, A-GNSS SET Assisted/Based only, Autonomous GPS, GNSS, AFLT, ECID, EOTD and OTDOA.	Enabling various LBS services by supporting different positioning technologies having low to high accuracy.
Network Support	Supports important networks including: LTE, WiMax, I-WLAN, and UMB.	Provides support for 4G networks increasing the ROI for 4G.
IP Based Communication	Internet Protocol (IP) based communication between SLC, SPC and SET.	Enables rapid deployment of solution with reduced TCO and maintenance costs for the customer.
TLS Based Communication	Supports TLS for communication between SLC and SET.	Ensures secure data communications between involved entities.

Typical Call Flow in User Plane Solution

Figure 2 below outlines a typical call flow in a SUPL solution. This example indicates a network initiated location request from a Location Services (LCS) client outside the operator's network. The position calculation happens with User Equipment (UE) in proxy mode while Gateway Mobile Location Center (GMLC) plays the SLP role.

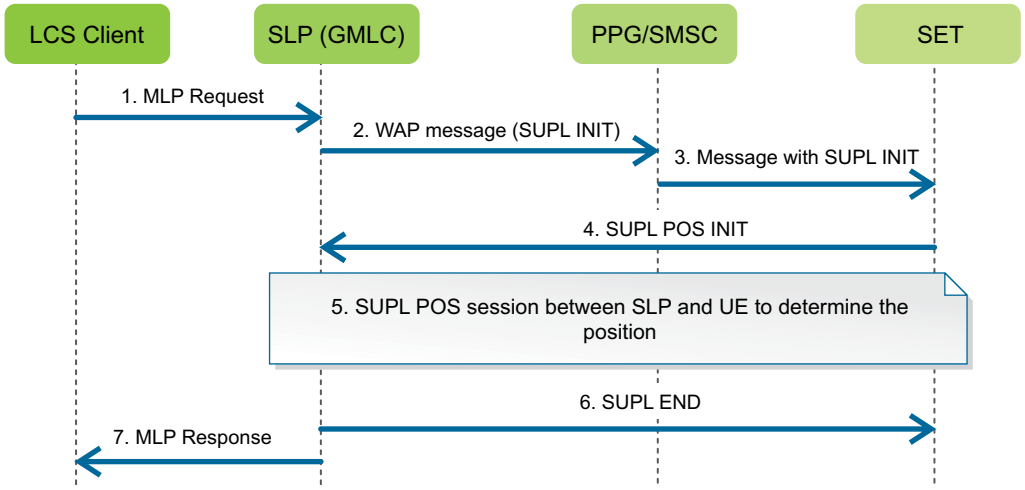

Figure 2: Typical Call Flow in User Plane Solution

1. The LCS Client sends a location request to the GMLC using the MLP protocol.
2. SLP (GMLC) initiates SUPL procedures to fetch the location information of the indicated UE. It sends out SUPL INIT message to UE through WAP/SMS or other viable mechanisms. SUPL INIT message contains IP address of SLP.
3. Once UE receives the SUPL INIT message, the UE initiates the internet protocol data session.
4. The UE sends a SUPL POS INIT message containing information such as its capabilities, supported positioning protocols (i.e. LPP/RRLP,), and initial position.
5. The LTE Positioning Protocol (LPP) session occurs between the SLP and the UE to determine the position of the UE. The LPP PDUs are exchanged by encapsulating them inside the SUPL POS.
6. Once the position calculation is done, SLP sends out SUPL END message to the UE.
7. SLP sends out Mobile Location Protocol (MLP) Response to the LCS Client.

Control Plane Solution

The control plane solution for delivering location information in LTE networks has been addressed by 3GPP. This solution helps provide a range of position accurate information to help address various regulatory requirements.

LTE Control Plane Solution Overview

The control plane architecture in LTE in order to delivery location information of UE is based on SMLC concepts, similar to earlier network types. Figure 3 below highlights key network elements and interfaces involved in delivering location information in a control plane solution.

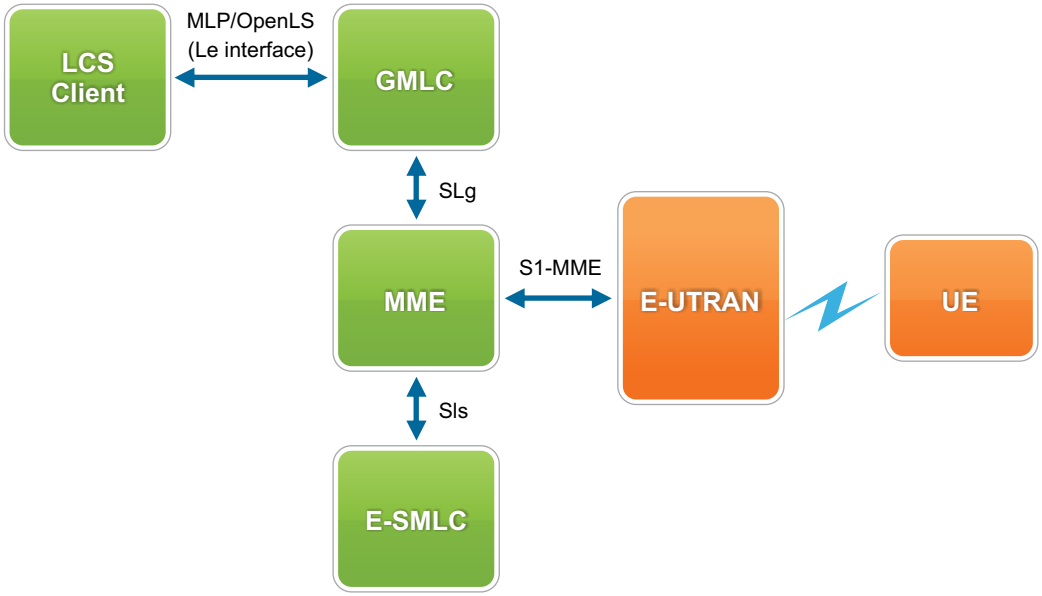

Figure 3: LTE Network Architecture to Enable LBS

Control Plane Network Elements

Gateway Mobile Location Center (GMLC): Receives a request from the external LCS clients and returns the location after it has been received from the network.

Mobile Management Entity (MME): Performs signaling and control functions to manage the user terminal and access various network resources. In addition, the MME provides procedures to receive the location information through the E-SMLC and E-UTRAN networks.

Evolved Serving Mobile Location Centre (E-SMLC): The MME triggers positioning requests by sending a request message to the E-SMLC, which supports location determination by communicating with eNodeB and UE using LPP and LPPa protocols. E-SMLC supports various position determination methods: Cell ID, ECID, OTDOA, UTDOA, GNSS based GPS, GLONASS, etc.

Evolved UMTS Terrestrial Radio Access Network (E-UTRAN): The radio network consisting of eNodeBs and UEs.

Control Plane Interfaces

SLg: SLg is a diameter based interface used by GMLC to request location information from the MME by using the following procedure:

1. Provide Subscriber Location Request: A message from GMLC to MME carrying the type of location information requested, QoS information, etc. for the MME.
2. Subscriber Location Report: A message from the MME to the GMLC conveying the identity of the UE, the location estimate, and its age.

SLs: An ASN.1 encoded interface used by the MME to request location information from the E-SMLC, utilizing the following methods:

1. Location Request:
   a. Current geographic location estimate: E-SMLC performs positioning procedure on the target UE using one or a combination of multiple positioning methods based on the UE capability
   b. Location assistance data for the target UE: The E-SMLC may further invoke the following LCS-AP procedures in order to receive assistance data:
      - Connection Oriented Information Transfer
      - Connectionless Information Transfer
2. Location Response: The eNodeB initiates the procedure by generating a Location Report message. This may be used as a response to a Location Reporting Control message.

S1-MME: The interface that may be used by the MME to provide cell based location information to the GMLC. The following procedures defined in the S1-AP specification may be used here.

1. Location Reporting Control: The MME initiates the procedure by sending a Location Reporting *Control* message. On receipt of this message the eNodeB performs the requested location reporting control action for the UE.
2. Location Report: The eNodeB initiates the procedure by generating a Location Report message. This message may be used as a response to a Location Reporting Control message.

Typical Call Flow in Control Plane Solution

Figure 4 below, is a typical example of a high level call flow in location determination in a Control Plane solution. This call flow is for the network initiated location request from the LCS client. The LPP communication process between the E-SMLC and UE is key position determination procedure. Other indicated interfaces enable the delivery of request and response to determine the location of the UE.

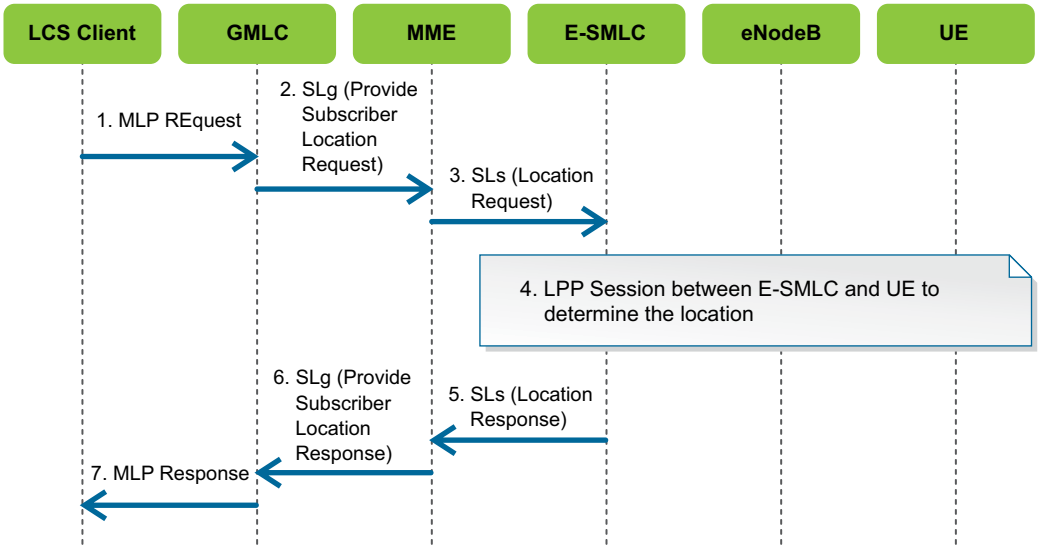

Figure 4: Typical Call Flow in Control Plane Solution

1. The first location request is sent from the LCS Client to the GMLC. The LCS client can reside outside the operator's network and the request can be as per the specification of MLP/OpenLS.
2. GMLC invokes the Provide Subscriber Location Request (PSLR) procedures of the MME to request the location information.
3. The MME then invokes the Location Request procedure from E-SMLC.
4. The E-SMLC initiates the LPP position determination sessions with the target UE. The LPP PDUs are tunneled through different protocols between the E-SMLC, MME, and eNodeB and the involved interfaces, S1-AP (MME-eNodeB) and LTE-Uu (eNodeB-UE).
5. After determining the location, the E-SMLC provides the location information to the MME by sending a Location Response.
6. The MME provides the location information to the GMLC by sending a Provide Subscriber Location Response.
7. The GMLC responds with the location information to the LCS Client.

Solution Comparison

The two solution options described above achieve the same goals. However, there are specific differences from the dimensions of technology support and market capabilities as compared below. The main differences lie in the procedures required to initiate location requests.

	User Plane - SUPL Solution	Control Plane Solution
Location Determination Procedures	Elements involved in the location determination process are defined by OMA and may reside outside the carrier's network. These include SLP – SLC and SPC. The positioning procedures remain the same for both approaches. They are as defined in LPP for 3GPP.	Elements involved in the location determination process are defined by 3GPP and mostly reside in the carrier's network. This includes MME, ESMLC and eNodeB. The positioning procedures remain the same for both approaches. They are as defined in LPP for 3GPP.
Positioning Technology Support	Methods supported include: - Assisted GNSS - OTDOA - ECID - AFLT These cover all methods from the Control Plane solution. In case of Assisted GNSS, SPC retrieves the assistance data from the GNSS reference network. Methods like OTDOA require help from the control plane elements such as E-SMLC, where assistance data from the network (eNodeB) is required.	Methods supported include: - Assisted GNSS - OTDOA - ECID In case of assisted GNSS, E-SMLC retrieves the assistance data from the GNSS reference network.
Total Cost of Ownership (TCO) and Deployment Consideration	Total cost of ownership is less as compared to control plane solution considering the IP elements involved. Hosted solutions are available in the market that can help reduce the infrastructure needs of operators/vendors.	Total cost of ownership can be high considering specific network elements such as E-SMLC need to be deployed with support for location determination. This solution is more carrier dominant since the key elements such as MME, E-SMLC, eNodeB are owned by carriers.
Location Applications Support	Apart from location access, SUPL provides support for additional features such as periodic and area event triggers, TLS security over internet protocol network, and support for other networks such as WiMax, IWLAN.	Main support and contribution is in the mechanism of location access and positioning procedures.

The main difference between the User Plane and Control Plane Solution is in the procedures required to initiate location requests.

Total cost of ownership of the control plane solution is higher than the user plane solution for the following reasons:

- Specific network elements such as E-SMLC need to be deployed with support for location determination in the control plan approach
- There are available hosted solutions on the market for user plane approach that can reduce infrastructure needs for operators/vendors

Challenges and Monetization Opportunities

The solutions described above address various challenges discussed earlier in the report and provide monetization opportunities as follows.

Enabling Location Services over LTE Network to Improve ROI

- Technically both the methods can be utilized to enable location services in LTE networks.
- The SUPL method can be a quick solution with a more affordable investment. Further, Assisted- Global Navigation Satellite System (AGNSS) based methods can reduce the network infrastructure based investment.
- Additional features supported through SUPL specification can help in readily deploying certain location services such as periodic tracking, area based geo-fencing, etc.
- If there are legal restrictions to support emergency services such as 911 for subscribers, then the operators need network based location determination methods such as Observed Time Difference of Arrival (OTDOA). In this case, the AGNSS/SUPL combination alone will not work. Instead, SUPL or a control plane method with network based location determination would be required.

The SUPL method can be a quick solution with a more affordable investment. Further, Assisted-Global Navigation Satellite System (AGNSS) based methods can reduce the network infrastructure based investment.

Leverage Existing Investment of 3G Location Infrastructure for 4G Networks

In situations where the operator has already invested in existing 3G network location infrastructure, it could be expensive to upgrade for 4G as part of the 4G roll out. There are two possible alternatives for this situation:

1. If there already is a SUPL 1.0 deployment, this can be upgraded to SUPL 2.0 to support the LTE network. SUPL 2.0 has a 4G network support. As indicated above, SUPL 2.0 provides further features such as periodic and event based location tracking.
2. In cases where the handsets have dual capability to support 3G and 4G, then existing 3G location capabilities can be leveraged. Location determination can be done over the 3G network whereas 4G can be utilized for high end data services. However, this case needs to be validated with the applicable legal requirements such as emergency call support for standalone 4G network.

SUPL 2.0 can provide a competitive edge to handset vendors by enabling certain location services without dependency on operators.

Monetization Opportunities for Handset Vendors

SUPL 2.0 can provide a competitive edge to handset vendors by enabling certain location services without dependency on operators. SUPL 2.0 along with AGNSS technology can be deployed as standalone and can enable location determination of handset devices. Handset vendors would then need to deploy SUPL components such as SUPL Location Center (SLC and SPC) to enable an AGNSS based location determination. Mobile Devices can use the location information for applications such as navigation, tracking, social networking, etc. This provides handset vendors a competitive edge to ship some pre-installed services/features on their handsets independent of whether the operator provides location determination service to their subscribers.

Summary

Location methods available for the LTE can address an operator's challenges in improving ROI and rolling out an LTE network, as well as provide monetization opportunities for handset vendors.

- Location determination in LTE networks can be enabled through both control plane (3GPP) and user plane (SUPL – OMA) solutions.
- SUPL based method has evolved (2.0, 3.0 version) and has an edge over control plane based method under certain situations such as:
  - Only AGNSS based positioning is sufficient
  - Quick deployment with lower investment is required
  - Existing SUPL 1.0 solution is available.
- SUPL can also be leveraged by handset vendors to provide a competitive edge by enabling certain handset based location services such as navigation.
- The Control Plane solution is a carrier dominant solution capable of supporting all types of positioning methods. Carriers can take advantage of this by providing commercial services as well as meeting regulatory mandates.

References

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2 Market Research Report "Magic Quadrant for LTE Network Infrastructure", Gartner, May 2011

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4 UserPlane Location Protocol Version 2.0 - OMA-TS-ULP-V2_0-20080627-C

5 3GPP TS 23.271 - Functional stage 2 description of Location Services (LCS)

6 3GPP TS 36.305 - Stage 2 functional specification of User Equipment (UE) positioning in E-UTRAN

7 3GPP TS 29.172 - Evolved Packet Core (EPC) LCS Protocol (ELP) between the Gateway Mobile Location Centre (GMLC) and the Mobile Management Entity (MME); SLg interface

8 3GPP TS 29.171 - LCS Application Protocol (LCS-AP) between the Mobile Management Entity (MME) and Evolved Serving Mobile Location Centre (E-SMLC); SLs interface.

9 3GPP TS 36.355 - Evolved Universal Terrestrial Radio Access (E-UTRA); LTE Positioning Protocol (LPP)

10 3GPP TS 36.413 - Evolved Universal Terrestrial Radio Access Network (E-UTRAN); S1 Application Protocol (S1AP)

About Persistent Systems

Established in 1990, Persistent Systems (BSE & NSE: PERSISTENT) is a global company specializing in software product development services. For more than two decades, Persistent has been an innovation partner for the world's largest technology brands, leading enterprises and pioneering start-ups. With a global team of 6,600+ employees, Persistent has 300+ customers spread across North America, Europe, and Asia. Today, Persistent focuses on developing best-in-class solutions in four key next-generation technology areas: Cloud Computing, Mobility, BI & Analytics, Collaboration across technology, telecommunications, life sciences, consumer packaged goods, banking & financial services and healthcare verticals. For more information, please visit: www.persistentsys.com.

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Glossary

3G, 4G	3rd and 4th Generation networks
3GPP	3rd Generation Partnership Project
AFLT	Advanced Forward Link Tri-lateration
AGNSS	Assisted - Global Navigation Satellite System
AGPS	Assisted Global Positioning System
ASN.1	Abstract Syntax Notation One
ECID	Enhanced Cell ID
eNodeB	Evolved Node-B
EOTD	Enhanced Observed Time Difference
E-SMLC	Evolved Serving Mobile Location Center
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
GLONASS	Global Navigation Satellite System
GMLC	Gateway Mobile Location Center
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IP	Internet Protocol
I-WLAN	Interworking-wireless LAN
LBS	Location Based Services
LCS Client	Location Services Client
LPP	LTE Positioning Protocol
LPPa	LTE Positioning Protocol A
LTE	Long Term Evolution networks
MLP	Mobile Location Protocol
MME	Mobile Management Entity
OMA	Open Mobile Alliance consortium
OpenLS OpenGIS®	Open Location Services Interface Standard
OTDOA	Observed Time Difference of Arrival
PDU	Protocol Data Unit
PPG	Push Proxy Gateway
QoS	Quality of Service
S1-MME	Interface between MME and E-UTRAN
SET	SUPL Enabled Terminal
SLC	SUPL Location Center
SLg	Interface between GMLC and MME
SLs	Interface between E-SMLC and MME
SMLC	Serving Mobile Location Centre
SMSC	Short Message Switching Center
SPC	SUPL Positioning Center
SUPL	Secured User Plane Location (Mostly refers to SUPL 2.0 version)
TLS	Transport Layer Security
UE	User Equipment
ULP	User Plane Location Protocol
UMTS	Universal Mobile Telecommunications System
UTDoA	Uplink Time Difference of Arrival
WiMax	Worldwide Interoperability for Microwave Access network
WWRN	World Wide Reference Network