White Paper

Secure User Plane Location

Secure User Plane Location (SUPL) is an IP technology that was developed to support Location-Based Services (LBS) for wireless communications. Basic SUPL architecture is composed of a server or network equipment stack and a SUPL-enabled wireless handset. The server and handset operate as a separate network layer that requires minimal interaction with private signaling networks. SUPL can help wireless services providers to verify the revenue potential of the LBS market before investing in costly network upgrades. This white paper describes Broadcom's unique advantages as a provider of SUPL services and includes details on SUPL network architecture, SUPL call flows, and the protocols and interfaces used within SUPL systems.

October 2007

Introduction

This document was written for mobile network operators (MNOs), network equipment vendors (NEVs), and application developers who are creating programs and products for the Location-Based Services (LBS) market. It focuses on Secure User Plane Location (SUPL) as the most effective means for bringing LBS to subscribers quickly and economically, and describes Broadcom's extensive capabilities in support of LBS business opportunities. Location-Based Services are expected to generate billions of dollars in annual revenue within the next few years. While mobile device manufacturers stand ready to embrace LBS, MNOs have been cautious about entering the market due to the cost and complexity of modifying Control Plane (C-Plane) network elements and protocols to support location services. SUPL enables MNOs to support location services with the least possible impact on the C-Plane. SUPL is a separate network layer that performs many LBS functions that would otherwise be governed within the C-Plane, and is designed to work with existing mobile Internet systems. With SUPL, MNOs can validate the potential of the LBS market with a relatively small budget and few risks.

SUPL Overview

SUPL was developed by the Open Mobile Alliance[1] (OMA), a mobile communications industry forum that was created to bring open standards, platform independence, and global interoperability to the LBS market. More than 360 companies are represented in OMA, including MNOs and NEVs, wireless vendors, mobile device manufacturers, content and service providers, and other suppliers. SUPL standards acknowledge Assisted GPS (AGPS) as the most accurate location technology available today. As one of the only end-to-end suppliers of AGPS products and data services, Broadcom has established relationships with companies across all LBS industry segments. SUPL architecture is composed of two basic elements: a SUPL Enabled Terminal (SET) and a SUPL Location Platform (SLP). The SET is a mobile device, such as a phone or PDA, which has been configured to support SUPL transactions. The SLP is a server or network equipment stack that handles tasks associated with user authentication, location requests, location-based application downloads, charging, and roaming.

The core strength of SUPL is the utilization, wherever possible, of existing protocols, IP connections, and data-bearing channels[2]. SUPL standards are complementary to and compatible with C-Plane standards. SUPL supports C-Plane protocols developed for the exchange of location data between a mobile device and a wireless network,

[1] Go to www.openmobilealliance.org for more information on the OMA.

[2] Includes GSM, UMTS, GPRS, EDGE, CDMA, and WCDMA.

including RRLP[3] and TIA-8014[4]. SUPL also supports MLP (Mobile Location Protocol) and ULP (UserPlane Location Protocol). MLP is used in the exchange of LBS data between elements such as an SLP and a GMLC, or between two SLPs; ULP is used in the exchange of LBS data between an SLP and an SET.

Implementation: SUPL vs. C-Plane

Two functional entities must be added to the C-Plane network in order to support location services: a Serving Mobile Location Center (SMLC), which controls the coordination and scheduling of the resources required to locate the mobile device; and a Gateway Mobile Location Center (GMLC), which controls the delivery of position data, user authorization, charging, and more. Although simple enough in concept, the actual integration of SMLCs and GMLCs into the Control Plane requires multi-vendor, multi-platform upgrades, as well as modifications to the interfaces between the various network elements. As with any complex endeavor, the larger the scope of the program and the more parties that are involved, the greater the number of points at which failures can occur. LBS through SUPL is much less cumbersome. The SLP takes on most of the tasks that would normally be assigned to the SMLC and GMLC, drastically reducing interaction with Control Plane elements. SUPL supports the same protocols for location data that were developed for the C-Plane, which means little or no modification of C-Plane interfaces is required. Because SUPL is implemented as a separate network layer, MNOs have the choice of installing and maintaining their own SLPs or outsourcing LBS to a Location Services Provider such as Broadcom. The transition from C-Plane location technologies to SUPL AGPS location, where SLPs will assume many of the tasks that are performed by the GMLC or SMLC, is expected to be a process that operators will go through in incremental steps. Broadcom has addressed this by segmenting responsibilities between the Broadcom SLP product and existing GMLCs to avoid duplication of functionality.

AGPS for Location-Based Services

The “A” in AGPS, and the foundation of Broadcom’s mobile location products, is the assistance data provided to mobile AGPS devices through a wireless network. With this data, mobile devices equipped with AGPS can compute positions more quickly and in much more difficult environments. Traditional GPS receivers work best in open areas that offer an unobstructed line of sight to the GPS satellites orbiting overhead. In places where GPS signals are weak, obstructed, or scattered, as is the case inside an office building or in an urban canyon, traditional GPS receivers compute positions intermittently at best and frequently cannot compute positions at all. Through competitive trials and in unforgiving real-world applications, Broadcom’s AGPS technology has consistently delivered positions in places where

[3] Radio Resource LCS Protocol, 3GPP 04.31, v8.13.0.

[4] Telecommunications Industry Association 801-A, *Position Determination Service for cdma 2000® Spread Spectrum Systems*.

traditional GPS receivers fail. Broadcom's AGPS Server products have been in continuous commercial operation since 2002, serving over ten million subscribers with 99.999% annual uptime. Having evolved from this proven foundation, Broadcom's SUPL Server began participating in operator trials in Q2, 2005, with commercial sale of the Broadcom SLP targeted for Q4, 2005. The first phase of SUPL deployment will support complete functionality for AGPS positioning services.

Worldwide Reference Network

The performance of a mobile AGPS device depends on the number of satellites included in the assistance data it receives. Broadcom's Worldwide Reference Network (WWRN) is the leading source of such data in the mobile communications industry and has been a key factor in the commercial success of Broadcom's AGPS Server products. The WWRN is a global network of reference stations that continuously tracks all GPS satellites and forwards their data to redundant Data Hubs. Real-time data for the entire GPS constellation is streamed from the Hub sites to all Broadcom SLP targets, enabling a single SLP to provide assistance data or compute positions for mobile GPS devices anywhere in the world. Connectivity to the WWRN is handled through VPN or SSH over the public Internet for developer evaluation, operator trials and limited commercial introductions, and through private frame relay for larger commercial systems. The WWRN is a pivotal resource for mobile location services that rely on AGPS, not only because it frees MNOs from the enormous task of having to develop, monitor, and maintain a GPS reference network, but also because it offers AGPS performance benefits that cannot be matched by a regional reference network. With data for all GPS satellites readily available through the Broadcom SLP, MNOs can focus on delivering LBS applications that take advantage of fast, accurate positions anytime and anywhere.

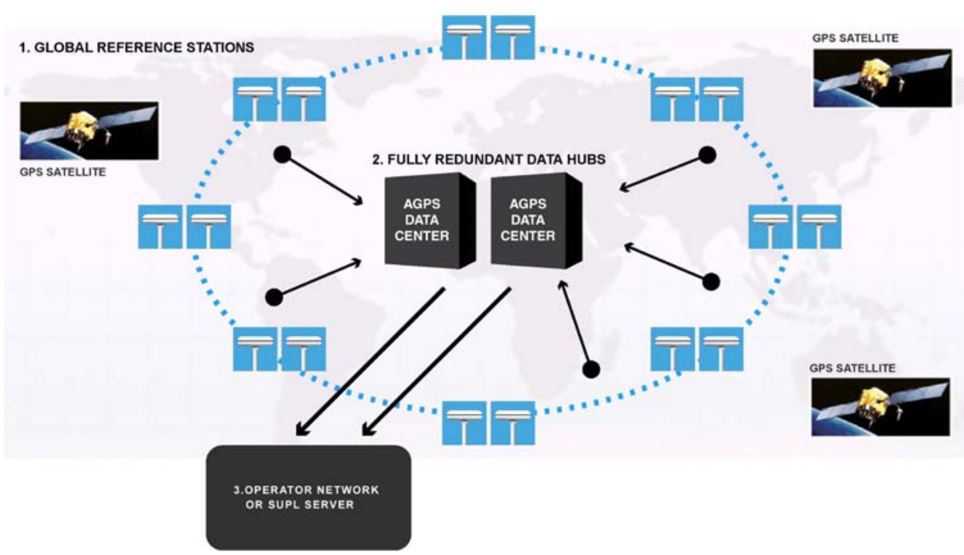

Figure 1: GPS Reference Stations and AGPS Data Hubs

LTO Data

Building from GPS satellite data accumulated by the WWRN, Broadcom also offers Long Term Orbit (LTO) data products. LTO is a complete set of orbit data for all GPS satellites that is modeled in advance[5] and is valid for up to several days. This extended validity period is a powerful resource for global roaming because it makes out-of-network AGPS operation possible for days at time. For example, upon arrival at an airport after an international flight, users may have difficulty connecting to the regional wireless network to get access to positioning services. LTO provides GPS assistance data that is largely unaffected by gaps in wireless service.

Worldwide Advantage

Broadcom has developed its AGPS products and services to meet the strict demands of the mobile communications market. Based on experience gleaned from commercial operations and in-depth collaboration with key middleware and NEV partners, the development of the Broadcom SUPL Location Platform represents a significant milestone in the pursuit of this goal.

With the introduction of its SUPL products, Broadcom is expanding its hosting infrastructure and offering hosted end-user applications, where mobile sets directly access the Data Hubs over IP connections. With total coverage of the GPS constellation through the WWRN, Broadcom's AGPS data services, including a hosted SLP solution, allow MNOs to offer their subscribers a mobile location utility capable of seamless roaming across markets, operators, and continents. By centralizing management of location services through Broadcom, MNOs can deliver LBS in several countries as easily as one. The benefit of worldwide AGPS coverage is obvious in the mobile communications business environment, where mergers between operators and consolidation of assets are commonplace.

[5] Long Term Orbit (LTO) data products use the WWRN streaming assistance data as raw data, and then compute predicted ephemeris for up to 10 days in the future. The raw ephemeris data is processed to account for the effects that impact the equations for satellite motion. The accuracy of position fixes using LTO is indistinguishable from that obtained using broadcast ephemeris for up to 48 hours. LTO is used in AGPS and SUPL Servers as a reserve-level backup capability should prolonged interruptions in connectivity occur.

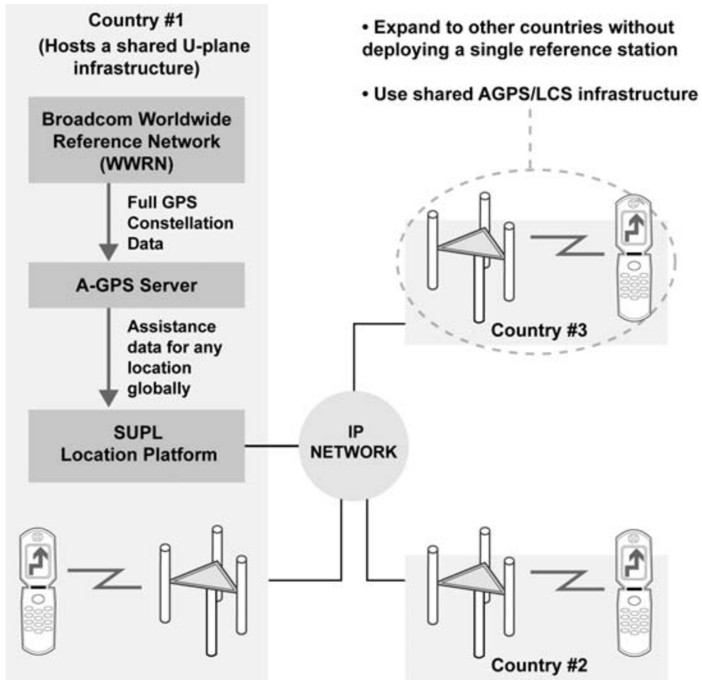

Figure 2: A Hosted SLP Network

Roaming standards defined in SUPL specifications can be divided into two basic approaches. In the first approach, the Visited SLP (V-SLP) may provide nothing more than the Cell ID of the tower being used by the roaming mobile set, and the position calculation is conducted between the roaming mobile set and the Home SLP (H-SLP) through a secure IP connection. In the second approach, the position calculation is conducted between the V-SLP and the roaming mobile set, again through a secure IP connection.

Either of these approaches requires that sufficient infrastructure be in place to support the position calculation. For AGPS positioning, this means that the SUPL Provider in the visited region must have GPS reference stations in the area in order to serve the roaming subscriber, or the SUPL Provider in the home region must have a GPS reference network large enough to cover the visited region.

The centralized "home roaming" approach offered by Broadcom helps MNOs to reduce infrastructure expense, interface management, and O&M (Operation and Maintenance), and also delivers meaningful performance advantages to subscribers. With the Broadcom SLP getting data for the full GPS constellation from the WWRN data feed, home roaming through Broadcom's SLP can serve subscribers in any visited network, enabling MNOs to not only avoid the expense of establishing and supporting a GPS reference network, but also to do away with the need to install V-SLPs or engage SUPL Providers in other regions. Because the Broadcom SLP can provide subscribers with GPS assistance data that is applicable wherever they may be roaming, there is no concern about what the visited network does or does not offer in terms of SLP availability or reference station coverage.

Moreover, the WWRN's unique ability to provide assistance data for all satellites on a continuous basis allows assisted GPS operation without precise Cell ID location. In many networks, especially while roaming, Cell ID location may not be available for all base stations. In the event that Cell ID location from the visited network is unavailable, the WWRN delivers the SET assistance data based on an approximate position, which could be obtained using a country and city code. In the case of LTO data, the assistance data can be valid for days into the future or can be supplied days in advance.

Through the combination of home roaming, the WWRN, and LTO, Broadcom's SUPL products and services can help bring the same practicality and reliability to LBS that subscribers expect from established mobile communication services.

Extra Points

In addition to the advantages explained above, the AGPS Server engine within the Broadcom SLP has two unique and patented technologies. First, the AGPS Server features a worldwide terrain model that allows positions to be computed with fewer satellite measurements. This feature also improves accuracy, particularly in hilly terrain. The model contains over one billion grid points, referenced to WGS84 (World Geodetic System 1984) with 18-meter altitude accuracy. Years of experience optimizing the AGPS Server platform and database access algorithms ensure that the terrain model's contribution to accuracy is delivered within milliseconds, transparent to the subscriber.

Second, with proprietary algorithms for processing pseudorange measurements, the AGPS Server can compute positions without accurate GPS time tags. This allows it to be deployed on networks that are not synchronized to GPS time, such as GSM and UMTS (3G). It also reduces the infrastructure burden for operators because it eliminates the need for LMUs (Location Management Units) that are used to bring GPS synchronization to base stations deployed in non-CDMA networks.

SLP Architecture

From the general overview in the previous section, this section expands detail on Broadcom's SLP product to a block diagram level as shown below in Figure 3, including interfaces to existing network elements.

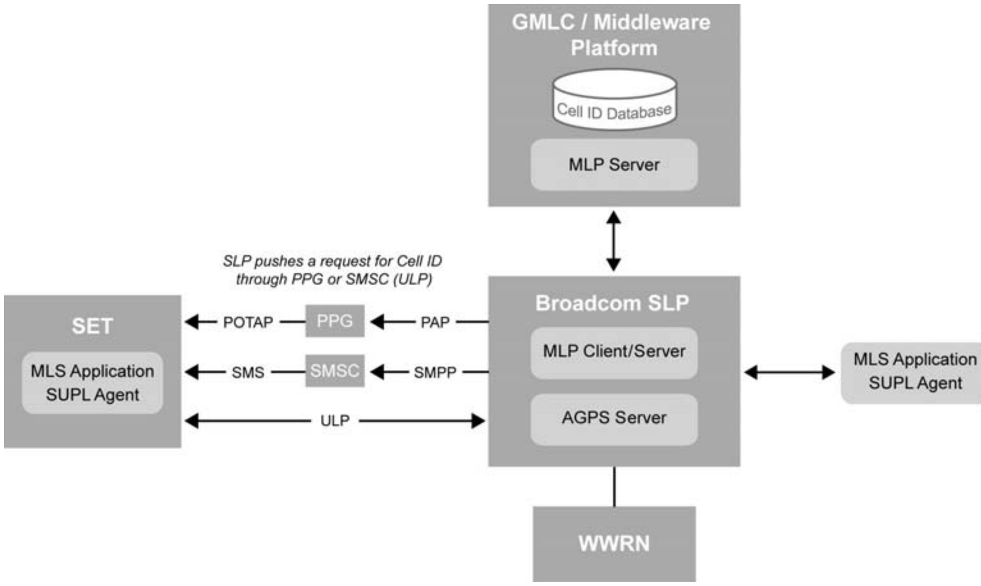

Figure 3: Block Diagram of SLP Architecture

SLP

Broadcom's SUPL Location Platform at the center of Figure 3 is responsible for all aspects of SUPL communication between the SET and the rest of the SUPL-enabled network. The SLP also provides all AGPS data services from the embedded AGPS Server engine, including providing assistance data and performing position computations.

SET

The SET block on the left of Figure 3 corresponds to the handset, but more specifically to the SUPL Agent that handles location transactions between the SET and the SLP. To support end-to-end SUPL trials, Broadcom offers a development kit for SUPL Agent software to customers of its GPS semiconductor products. Interaction between the SET and the SLP is done through ULP (UserPlane Location Protocol), a TCP/IP protocol that can be used over GPRS, EDGE, or any other air interface approved for use in SUPL systems.

GMLC/Middleware Platform

The GMLC, or Middleware platform, is often a pre-existing piece of equipment. The GMLC may do little more than provide an initial position based on the ID of the Cell tower being used by the SET. Communication between the SLP and the GMLC is conducted using MLP. The underlying transport mechanism is TCP/IP.

WWRN

The WWRN at the bottom center of Figure 3 provides GPS assistance data (satellite ephemeris, integrity, and more) to the AGPS Server within the SLP. The data comes from Broadcom Data Hubs, typically through frame relay or, for smaller installations, through VPN over the public Internet. The interface uses a Broadcom proprietary streaming format; the specific transport mechanism is User Datagram Protocol (UDP).The SLP receives data streams from all sources of WWRN data simultaneously, providing deep redundancy and robust fault protection.

LBS Application/SUPL Agent

An LBS application is any application that requests and uses location information, such as a navigation, tracking, or “friend-finder” application. SUPL Agent software is responsible for gaining access to the network resources required for the location session.

SMSC and PPG Interfaces

These interfaces support SET notification. For network-initiated call flows, the SLP first notifies the SET, and the SET must then establish an IP connection to the SLP. SET notification can be done through SMS (Short Message Service) from the SLP through an SMSC (Short Message Service Center) using SMPP (Short Message Peer-to-Peer) protocol, or a WAP push (Wireless Application Protocol) to a PPG (Push Proxy Gateway).For communication through either an SMSC or PPG, the underlying data bearer is again TCP/IP—a common trait throughout the SUPL standard.

Call Flows

In the network-initiated and SET-initiated call flows detailed below, the GMLC does nothing more than provide the initial position for the position calculation sequence that is conducted between the SLP and the SET.

The SLP and the SET communicate through ULP, a binary protocol that supports eight basic messages. These messages are used to initiate a SUPL session, exchange positioning and authentication data, and end a SUPL session.

Communication between the SLP, the Client application, and the GMLC is done through MLP. Only two MLP message types, SLIR (Standard Location Immediate Request) and SLIA (Standard Location Immediate Answer), are used in either transaction sequence. This is important because although MLP is very complex, utilization of MLP in SUPL architecture is not.

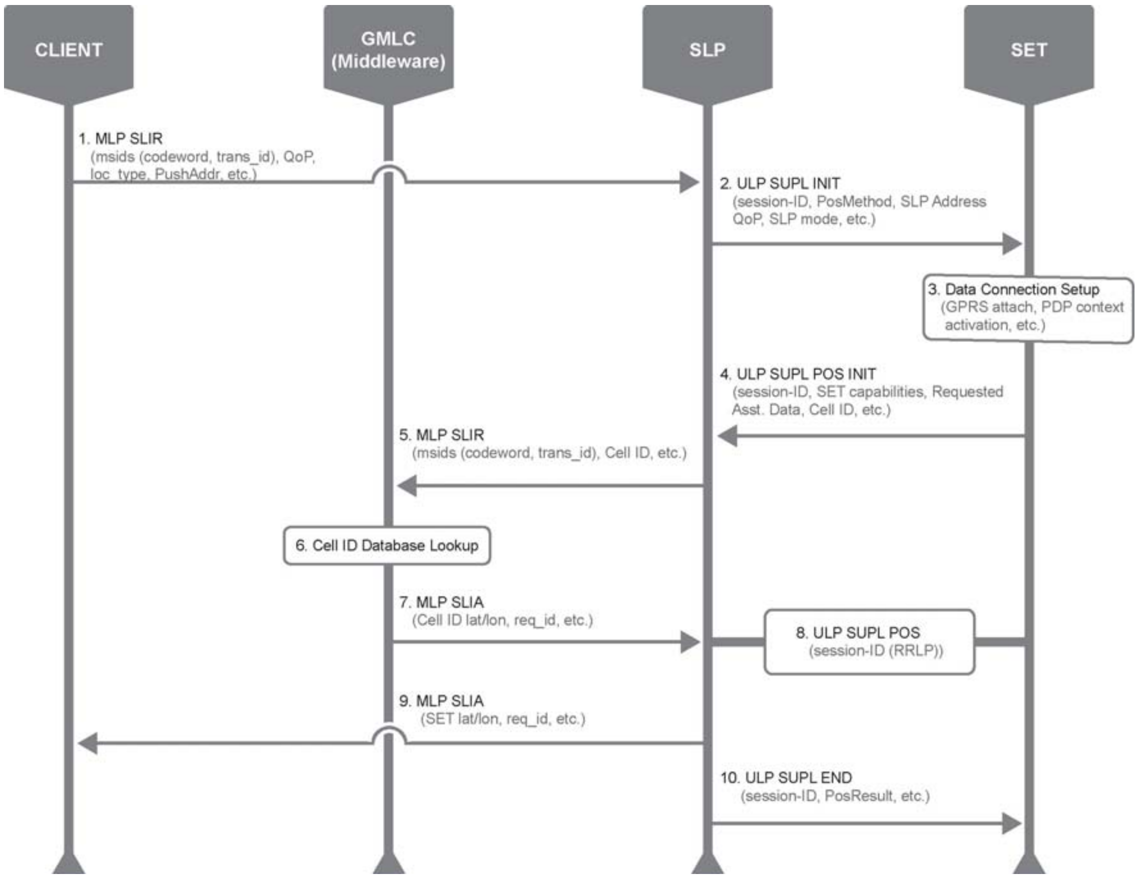

Figure 4: Network-Initiated Request

Step 1. The Client application queries for the location of the targeted SET by sending an SLIR message (Standard Location Immediate Request) to the SLP. The message contains an ID for the targeted SET, positioning preferences, routing information, and a transaction code. The SLP authenticates the request and then determines whether the transaction will be based on AGPS or another positioning resource.

Step 2. The SLP sends a SUPL INIT message to the targeted SET through SMS or WAP push. The message contains an access code, an address for the SLP, parameters for the positioning method that will be used, and a unique, SLP-generated Session ID.

Step 3. The SET authenticates the access code and connects to an IP network through GPRS, EDGE, or other means.

Step 4. The SET establishes a secure connection with the SLP and sends a SUPL POS INIT message to it. The message contains the ID of the Cell tower being used by the SET (Cell ID), a profile of the SET's capabilities, a request for assistance data, and a unique Session ID generated by the SET. The SUPL POS INIT also contains a "hash", or cryptographic distillation, of the SUPL INIT message that the SLP uses to authenticate the SUPL POS INIT message.

Step 5. The SLP authenticates the hash and sends an SLIR message to the GMLC to get a coarse position for the SET. The message contains the SET ID, an access code for the SET, and the ID of the Cell tower being used by the SET.

Step 6. The GMLC authenticates the request, then queries its Cell ID database to find the latitude and longitude of the Cell ID referenced in the SLIR message. The latitude and longitude of the Cell ID will serve as the initial position for the position calculation.

Step 7. The GMLC sends an SLIA message to the SLP. The message contains the SET's coarse position and an ID number that corresponds to the access code sent in Step 5.

Step 8. The SLP authenticates the ID number and sends a SUPL POS message to the SET to start the position calculation process based on the coarse position sent by the GMLC. The message contains a unique Session ID that combines the Session IDs generated by the SLP and the SET in steps 2 and 4. This combined Session ID will be used in all of remaining messages exchanged between the SET and the SLP.

The SUPL POS message encapsulates a message from one of the approved positioning protocols (RRLP6, TIA-801, or RRC). The SET and the SLP may exchange several SUPL POS messages while performing the position calculation.

Step 9. The position calculated for the SET is sent back to the Client application in an SLIA message. The message contains the latitude and longitude of the SET as well as an ID number that corresponds to the transaction code sent in Step 1.

Step 10. After sending the position of the targeted SET to the Client application, the SLP sends SUPL END message to the SET. This is the end of the transaction as far as the SLP and SET are concerned, although the GMLC or the Client application may have additional tasks to complete.

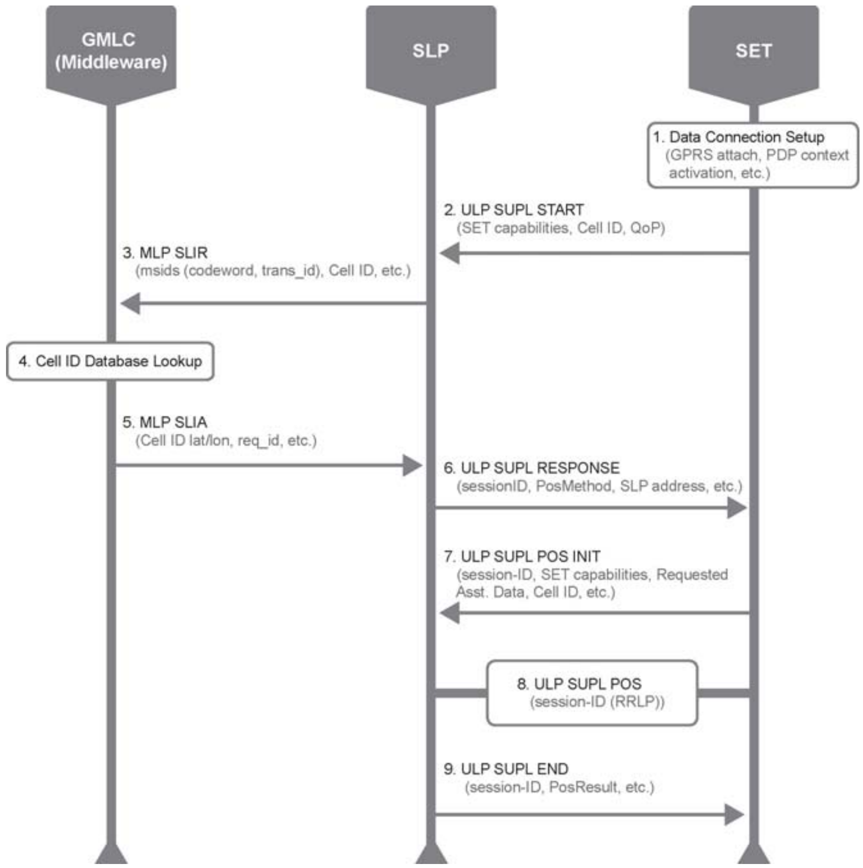

Figure 5: SET-Initiated Request

Step 1. The SET connects to an IP network through GPRS, EDGE, or other means.

Step 2. The SET establishes a secure connection with the SLP sends a SUPL START message. The message contains the ID of the Cell tower being used by the SET (Cell ID), a profile of the SET's capabilities, parameters for the positioning method, and a unique, SET-generated Session ID.

Step 3. The SLP sends an SLIR message to the GMLC to get a coarse position for the SET. The message contains the SET ID, an access code for the SET, and the ID of the Cell tower being used by the SET.

Step 4. The GMLC authenticates the request, then queries its Cell ID database to provide a latitude and longitude for the Cell ID referenced in the SLIR message. The latitude and longitude of the Cell ID will serve as the initial position for the position calculation.

Step 5. The GMLC sends an SLIA message to the SLP. The SLIA message contains a latitude and longitude for the Cell tower being used by the SET and an ID number that corresponds to the access code sent in Step 3.

Step 6. The SLP sends a SUPL RESPONSE message to the SET, which identifies the positioning method that will be used, and contains a unique Session ID that is a combination of the Session ID generated by the SET and a Session ID generated by the SLP. This compound Session ID will be used in all of the remaining messages exchanged between the SET and the SLP. The SUPL RESPONSE message may also contain an address for the SLP and authentication data if the transaction requires authorization.

Step 7. The SET sends a SUPL POS INIT to the SLP. This message contains some of the same elements as the SUPL START message, but also contains a request for assistance data.

Step 8. The SLP sends a SUPL POS message to the SET to start the position calculation process based on the coarse position sent by the GMLC. The SUPL POS message encapsulates a message from one of the approved positioning protocols. Several SUPL POS messages may be exchanged between the SET and the SLP during the position calculation.

Step 9. The SLP sends a SUPL END message to the SET declaring that the transaction has ended. This is the end of the session for the SET and the SLP, but the GMLC may perform additional tasks outside session.

Interfaces

As part of the SUPL call flows described above, the Broadcom SLP also communicates through the interfaces described in this section.

MLP Interface

As discussed in previous sections, the Broadcom SLP uses the MLP (Mobile Location Protocol) interface both as a Server and a Client, serving location requests from an LBS application or an SET, and requesting data from a GMLC or middleware entity.

This interface is also used to authenticate and record SET requests in the GMLC. In each case, whether the SLP is acting as a Server or Client, and regardless of the transaction type, only two MLP messages are used: SLIR and SLIA.

PAP (Push Access Protocol)

In a network-initiated SUPL call flow, the SLP may use WAP Push to send a SUPL INIT message to a given SET through a Push Proxy Gateway (PPG). The SUPL INIT message is sent to the PPG in the form of a PAP message. The PPG then forwards the SUPL message to the targeted SET by sending a POTAP message through the air interface. Refer to OMA specifications[6] for more details.

[6] Go to http://www.openmobilealliance.org/tech/affiliates/wap/wap-247-pap-20010429-a.pdf to get more information on PAP.

SMS (Short Message Service)

SMS is a text messaging service for wireless communications. Because an SMS message can also carry binary data, SMS can be used to carry the SUPL INIT message to the targeted SET in a network-initiated SUPL call flow.

ULP Interface

ULP (UserPlane Location Protocol) is a binary protocol used for communication between the SLP and the SET. ULP is composed of eight messages that are used to initiate a SUPL location session, exchange authentication data, conduct position calculations, and end a SUPL location session.

Operation and Maintenance

Web Interface

Broadcom's SLP Server has a Web-based interface for operation and maintenance and features a variety of Status pages, an SLP Utilization page, and a Configuration page. The underlying O&M communication with the SLP is based on SNMP v2 and supports integration to commercial network monitoring systems such as HP OpenView, NetCool, or NetAct. The Web-based interface provides fast and simple O&M integration, enabling development and interoperability trials, and also provides extensibility into commercial operations.

SLP Status Page

If the Status page indicates a "Ready" state, all embedded AGPS Server and interface modules within the SLP are fully functional. The specific readiness of these states is indicated as described below.

AGPS Server Status

The Assistance data availability table lists the PRN (Pseudo-random Noise) codes of satellites whose full assistance data is available. Availability is given only for Healthy satellites. This list omits satellites undergoing scheduled maintenance or maneuver, or satellites subject to unscheduled outages, as defined by NANU (Notice Advisory to NavStar Users) messages available to the civilian sector from the US Air Force and the US Coast Guard.

WWRN Feed Status (Active/Inactive)

WWRN Feed Status confirms streaming connectivity to both of Broadcom's Data Hubs. Status Inactive indicates an ongoing loss of the WWRN feed.

LTO Status

Once computer, LTO data is valid for 48 hours once computed and is recomputed hourly at the Data Hubs and sent to all AGPS Server and SLP targets on the WWRN data feed. While the WWRN data feed remains active, *t remaining* time will be within one hour of 48 hours. If WWRN feed status becomes inactive for longer than one hour, LTO will not be refreshed, and the value under *t remaining* will begin to decrease.

In the event of a prolonged loss of the WWRN data feed, the AGPS Server will switch to LTO data. LTO Status Active means the AGPS Server is running on LTO data.

External Interface Status

- TCP/IP connection status to GMLC (Active/Inactive)
- TCP/IP connection status to PPG (Active/Inactive)
- TCP/IP connection status to SMSC (Active/Inactive

Utilization Page

- Peak utilization information (peak transactions per hour)
- Current license information (allowed transactions per hour)

Configuration Page

Very little configuration is required for the SLP. On this page, a table containing the necessary IP addresses is displayed, and is accessible for configuration through username/password security. The serial number and expiration status of the Broadcom license file are also accessible from this page.

Appendix A: MLP Client / Server Examples

SLP as MLP Server: Request for the location of an MSID, sent from the requesting entity to the SLP.

```
<slir ver="3.2.0" res_type="SYNC">
      <client>
            <id>theLES</id><pwd>thepwd</pwd>
            <serviceid>408</serviceid>
      </client>
            <msid type="MSISDN">
            <msid>461018765710</msid>
      <eqop>
            <resp_req type="LOW_DELAY" />
            <hor_acc>1000</hor_acc>
      </eqop>
      <loc_type type="CURRENT" />
      <prio type="HIGH" />
</slir>
```

Location answer from the SLP:

```
<slia ver="3.2.0">
      <pos>
            <msid>461011334411</msid>
            <pd>
                  <time utc_off="+0200">20020623134453</time>
                  <shape>
                        <EllipticalArea>
                              <coord>
                                    <X>30 16 28.308N</X>
                                    <Y>45 15 33.444E</Y>
                              </coord>
                              <semiMajor>150</semiMajor>
                              <semiMinor>275</semiMinor>
                        </EllipticalArea>
                        <alt>46</alt>
                        <alt_acc>2</alt_acc>
                  </shape>
            </pd>
      </pos>
</slia>
```

SLP as MLP client: initial location request from the SLP to a position-serving entity.


```
<slir ver="3.2.0" res_type="SYNC">
      <client>
            <id>GLSLP2</id><pwd>thepwd</pwd>
            <serviceid>408</serviceid>
      </client>
      <msid type="IPV4">
      <msid>190.123.0.144</msid>
      <requestor>
            <id>theSETapp</id>
            <serviceid>505</serviceid>
      </requestor>
      <mcc>310</mcc><mnc>1</mnc><lac>1</lac><cellid>100</cellid>
      <loc_type type="INITIAL" />
      <prio type="HIGH"/>
</slir>
```


Location answer from the position-serving entity:


```
<slia ver="3.2.0">
      <pos>
            <msid>461011334411</msid>
            <pd>
                  <time utc_off="+0200">20020623134453</time>
                  <shape>
                        <EllipticalArea>
                              <coord>
                                    <X>30 16 28.308N</X>
                                    <Y>45 15 33.444E</Y>
                              </coord>
                              <semiMajor>150</semiMajor>
                              <semiMinor>275</semiMinor>
                        </EllipticalArea>
                  </shape>
            </pd>
      </pos>
</slia>
```

Appendix B: RRLP Call Flow

The information in this appendix is based on the 3GPP technical specification for RRLP (3GPP TS 04.31, version 8.5.0). The 3GPP specification defines one basic message to show how location data is transferred between a mobile station and a Serving Mobile Location Center (SMLC). In this appendix, the mobile station is understood to be a SUPL Enabled Terminal (SET), and the SUPL Location Platform (SLP) will take the place of the SMLC. Please note that RRLP messages used in SUPL systems will be encased within a SUPL "envelope" protocol (ULP, or UserPlane Location Protocol) that is used in the exchange of data between the SET and the SLP.

The process illustrated below is represented in Step 8 of the network-initiated call flow (Figure 4) and the SET-Initiated call flow (Figure 5).

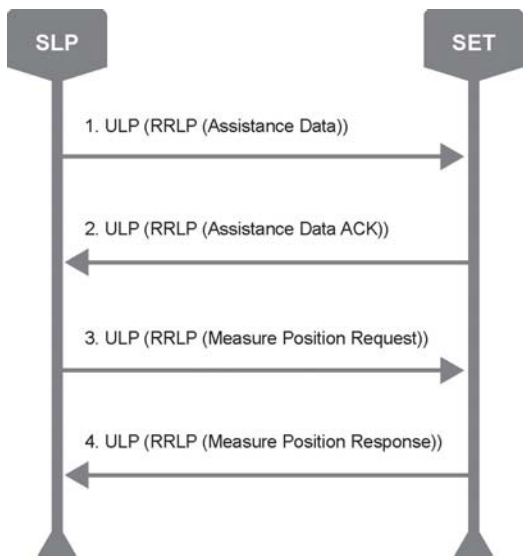

Figure 6: ULP/RRLP Call Flow

The SLP sends an Assistance Data packet to the SET. The assistance data may be sent in more than one packet. Each packet contains a reference number for delivery, assistance data for position measurement or position calculation (or both), and an element that indicates whether another packet of assistance data is forthcoming for the current session.

When the SET has received the complete set of assistance data, it sends an Assistance Data Acknowledgment packet to the SLP. The acknowledgment packet contains the reference number(s) of assistance data packet(s) received by the SET.

The SLP sends a Measure Position Request packet to the SET. The packet contains a reference number for the request, response time, accuracy, positioning method, and other instructions.

The SET sends a Measure Position Response packet to the SLP. If the position calculation is performed on the SLP, the packet contains a host of GPS measurement information, including satellite IDs, carrier-to-noise ratio, Doppler measurements, multipath indicator, pseudorange error, and more. If the position calculation is performed on the SET, the packet contains all of the preceding data plus location data: GPS time of week at which the position calculation occurred, the position fix type (2D or 3D), and the position estimate calculated by the SET.

RRLP Error Handling

Both the SET and the SLP send an error packet in the event an incomplete or corrupted packet is received. The error packet contains a reference number for the corrupted packet, if available, and includes a specific notation for the type of error detected in the corrupted packet, such as Undefined, Incorrect Data, Unknown Reference Number, Missing Data, and others. If the SET receives an incomplete assistance data packet, it sends an error packet to the SLP, and the SLP responds either by resending the same assistance data or by sending an updated set of assistance data.

Appendix C: Glossary

Term	Definition
AGPS	Assisted GPS. A method of GPS positioning whereby the GPS receiver is assisted in calculating positions by getting GPS ephemeris data through a means other than directly from the GPS satellites.
CDMA	Code Division Multiple Access. A multiplexing spread spectrum radio Signaling method that allows multiple transmitters to simultaneously send to a receiver on the same frequency without causing interference.
C-Plane	Control Plane. The private Signaling network and related infrastructure that provides wireless communication services to authorized subscribers.
EDGE	Enhanced Data Rates for GSM Evolution. An enhancement to GPRS networks that can support data rates up to 384 kbps. EDGE was developed to support high bandwidth applications such as Internet connection and multimedia exchange.
E-OTD	Enhanced Observed Time Difference. A time-based method of position calculation in which arrival times of signals from three or more cellular base stations and the known locations of the base stations are used by a mobile handset to triangulate its position.
GPRS	General Packet Radio Service. A packet switched mobile data service that takes advantage of unused network bandwidth and provides data rates of 30 to 70 kbps.
GSM	Global System for Mobile Communications. A digital wireless service for voice and data communications. GSM is an open standard being developed by the 3GPP.
H-SLP	Home SLP. The SLP that serves a subscriber's home wireless network.
LBS	Location-Based Services. An extension of LCS that includes a wide variety of real-time services and takes advantage of burgeoning wideband wireless communication services.
LCS	Location Services. A generic term for services and related applications that are based on the geographic location of a mobile device, and are channeled primarily through wireless communication networks.
LSP	Location Services Provider. A mobile network operator or SUPL provider that manages location services for LBS subscribers.

MLP	Mobile Location Protocol. An application-level protocol for sending and receiving the location information of a mobile device such as a mobile phone or wireless PDA. MLP is the data interface used between SUPL providers, or between a SUPL provider and a mobile network operator. MLP is an XML language, and as such is not dependent on a particular network technology or data bearing channel.
MNO	Mobile Network Operator. A company that sells wireless communication services and owns the wireless communications infrastructure that makes the services possible.
MSID	Mobile Station Identifier. The unique identifier for a mobile communications subscriber.
PAP	Push Access Protocol. A protocol that uses MIME elements to send XML data to a PPG server, and from the PPG to a mobile device such as a mobile phone or wireless PDA. By definition, the information sent through the PPG has not been requested by the mobile device. PAP is an Internet protocol and is not intended for use over the air.
PPG	Push Proxy Gateway. A WAP server configured to deliver information to a mobile device independent of an explicit request from the mobile device. In the context of SUPL, the SLP can initiate a session with the SET by sending it a SUPL INIT message. In this case, the SUPL INIT message would be sent from the SLP to the PPG over the Internet using PAP, and would be sent from the PPG to the SET using POTAP, a wireless interface.
POTAP	Push Over The Air Protocol. A protocol layer designed for wireless communication that is used to send information from a PPG to a mobile device. POTAP is based on WSP (Wireless Session Protocol), a binary protocol derived from HTTP.
RLP	Roaming Location Protocol. A protocol that serves as the interface between two location servers. In the context of SUPL, RLP would be used in communications between a V-SLP and an H-SLP. RLP adheres to Mobile Location Protocol (MLP) structure.
RRC	Radio Resource Control. A C-Plane protocol that is used to control Signaling and transfer of information between the mobile handset and radio network control elements. RRC supports the exchange of data for AGPS and E-OTD positioning.
RRLP	Radio Resource LCS (Location Services) Protocol. A protocol developed for EDGE that enables a mobile handset to exchange position information with position serving entity such as an SLP. RRLP supports both AGPS and E-OTD positioning.
SET	SUPL Enabled Terminal. A device that can communicate with a SUPL network. Communication with the SUPL network is handled by SUPL Agent software running on the device. An SET could be a mobile phone, wireless PDA, PC, or any other device that can connect to an IP network.

SLIA	Standard Location Immediate Answer. The MLP message sent in response to an SLIR message. The SLIA message contains a unique ID number for the request, the ID of the targeted mobile device, the position of the mobile device, the time at which the position was calculated, and more.
SLIR	Standard Location Immediate Request. The MLP message used to request the location of a mobile device. The SLIR message contains ID of the targeted mobile device, an access code for obtaining the position of the mobile device, quality of position (QoP) and positioning priority, the ID of the service or application that is requesting the position of the mobile device, and more.
SLP	SUPL Location Platform. A server or network stack that provides positions or position assistance data to an SET, and also supports functions related to roaming, security, authentication, charging, and more.
SMPP	Short Message Peer-to-Peer. A protocol that enables “peer” network entities to send and receive SMS messages, such as an SMSC forwarding an SMS to another SMSC. In the context of SUPL, SMPP is the protocol used between the SLP and the SMSC.
SMS	Short Message Service. A mobile communications service that enables subscribers to send short text messages between mobile phones and other wireless handheld devices. Messages are sent through an SMSC to the intended recipient. Short messages can also be used to send binary data. In the context of SUPL, an SLP would send a SUPL INIT message to the SMSC using SMPP, and the SMSC would encapsulate the SUPL INIT message in an SMS message and forward it to the intended SET.
SMSC	Short Message Service Center. A network entity that receives and forwards SMS messages.
SUPL	Secure User Plane Location. A network layer that uses established data-bearing channels and positioning protocols for the exchange of location data between a SUPL Enabled Terminal (SET) and a SUPL Location Platform (SLP). SUPL is a key enabling technology for Location-Based Services (LBS).
TIA-801	Telecommunications Industry Association Specification 801, Position Determination Service for cdma2000® Spread Spectrum System. The TIA specification that defines communications between a mobile station and a base station for mobile positioning services in a cdma2000 network.

UDP	User Datagram Protocol. A transport layer protocol that was created to enable simple messaging between the application layer and the network layer. Unlike TCP, UDP has no mechanism for ensuring that UDP packets are delivered in the correct order and gives no indication that a packet has or has not been delivered. UDP is one of the core IP protocols.
ULP	UserPlane Location Protocol. A TCP/IP protocol based on ASN.1 that supports the exchange of data between an SET and an SLP. In addition to location data, ULP also handles the exchange of authentication data.
UMTS	Universal Mobile Telecommunications System. An all-digital wireless communication service that combines the WCDMA air interface with GSM routing and digitizing standards to support broadband multimedia telecommunication services
VSLP	Visited SLP. An SLP used by a subscriber who is roaming outside of his or her home network.
WAP	Wireless Application Protocol. An open standard protocol that allows mobile wireless devices to connect to the Internet. WAP provides some of the functions as a standard Web browser, but has additional features to compensate for the processing and display limitations of mobile devices.
WCDMA	Wideband Code Division Multiple Access. A wideband radio Signaling method that uses the same multiplexing scheme as CDMA, but also includes a complete set of specifications that define signal modulation, datagram structures, interface protocols, and more. WCDMA is the air interface used in UMTS systems.

Appendix E: References

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