

Adding Location-Based Services to Existing Architectures

Building Feature-Rich Mobile Telephony Applications Using Dialogic® Signaling Components



Executive Summary

This application note provides an overall view of Location-Based Services (LBS), describes the signaling and technology involved, and discusses how Dialogic® signaling components can be used in implementing such services.

Beginning with an overview of the LBS network architecture, this application note discusses positioning mechanisms used by Global System for Mobile Communications (GSM) LBS service providers, and provides two examples of signaling flows for LBS service scenarios.

System designs are also considered, showing how high performance LBS application platforms can be developed with Dialogic® Signaling Distributed Architecture (SigDiA) building blocks, enabling system designers to offer location-based services worldwide.



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Introduction

Location-Based Services (LBSs) provide the ability to deliver high-value content to an end user, based on knowledge of the end-user's location.

Applications include:

- **Information services** — Events, traffic, location-relevant services normally initiated by a mobile handset user
- **Tracking** — Fleet management, asset tracking, and people tracking
- **Advertising and marketing** — Location-based ads and location-sensitive pages normally sent to a mobile handset user

For high-value content to be delivered to an end user, an LBS must know the location of the mobile handset. The following sections discuss GSM network elements designed to support LBS services, as well as positioning mechanisms that can be used by mobile networks.

LBS Network Architecture

Adding an LBS to an existing GSM network requires adding several LBS network elements. These elements, shown in green in Figure 1, enable the network to determine the location of a particular mobile handset [3GPP TS 03.71].

- **Location Services Client** — The LBS service application that either initiates LBS queries or responds to LBS queries from a mobile handset.
- **Gateway Mobile Location Center (GMLC)** — The connection to the mobile network for the client's LBS service application. The GMLC sends requests for mobile handset location information to a Mobile Switching Center (MSC) and receives the results of such requests. The GMLC can also request routing information from the Home Location Register (HLR). (Mobile Application Part [MAP] connections to the GMLC are via "Lh" and "Lg" interfaces as described in [3GPP TS 03.71].)

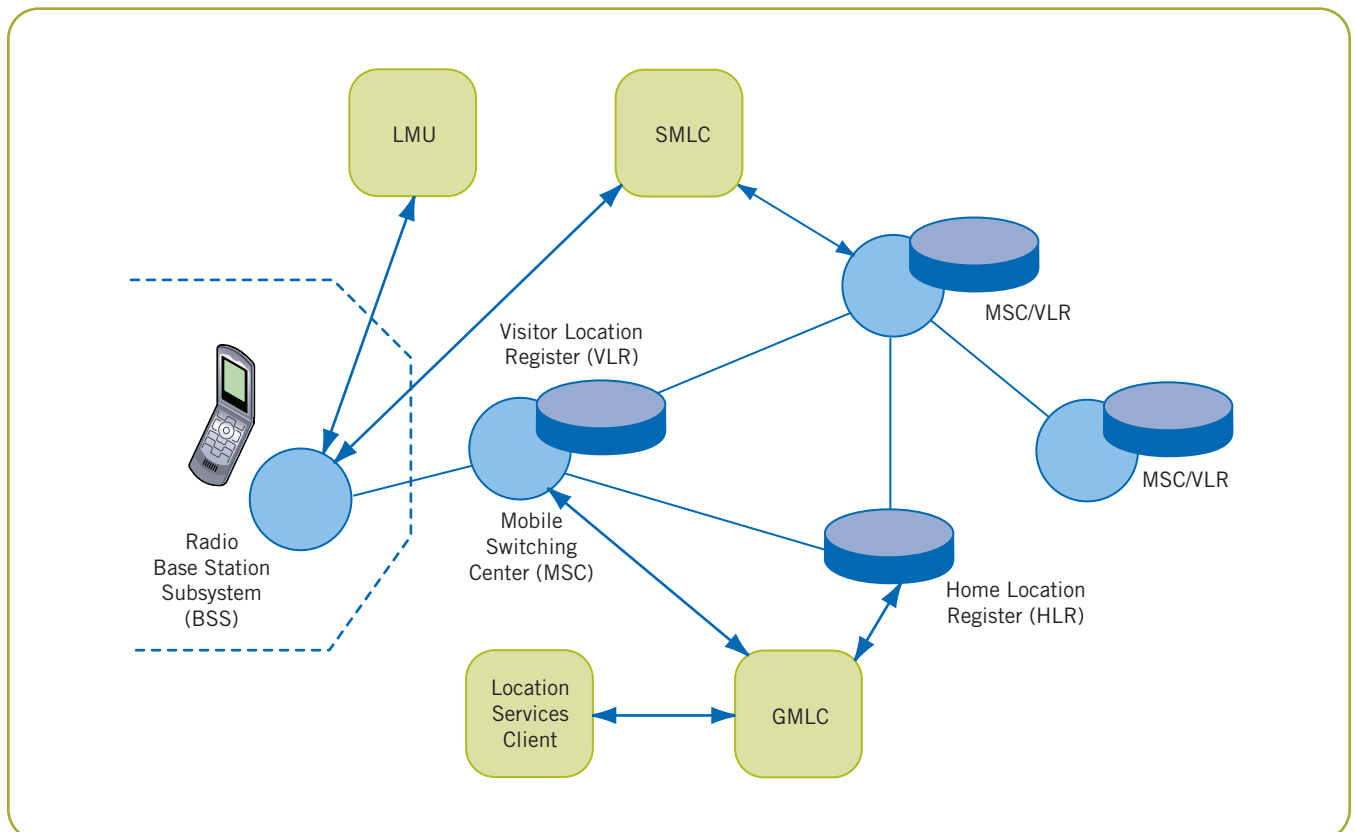


Figure 1. Adding LBS to the GSM Network

- **Location Measurement Unit (LMU)** — Connects with the Base Station Subsystem (BSS) of the GSM network and takes radio measurements to support a location-based service.
- **Serving Mobile Location Center (SMLC)** — Controls a series of LMUs in order to receive radio interface timing measurement information. From this information, the SMLC can determine a mobile handset's position, plus give an indication of the accuracy of positioning information.

Note: The SMLC and GMLC functions could be parts of a single network element.

Positioning Mechanisms

There are a number of positioning mechanisms that could be used by mobile operators seeking to provide an LBS service. The 3rd Generation Partnership Project (3GPP) currently proposes a number of methods [3GPP TS 03.71].

- Uplink Time of Arrival (TOA)
- Enhanced Observed Time Difference (E-OTD)
- Global Positioning System (GPS) Assisted

Uplink Time of Arrival (TOA)

This positioning method utilizes the fact that radio waves travel at the speed of light; therefore, the propagation delay for a signal to travel a known distance is constant.

The uplink TOA mechanism requires three or more network Location Measurement Units (LMUs) (see Figure 1) to measure the arrival time of a signal sent from a mobile handset (see Figure 2). The difference in arrival time of the mobile signal at different network LMUs is used by the network's Serving Mobile Location Center (SMLC) to determine the handset's location.

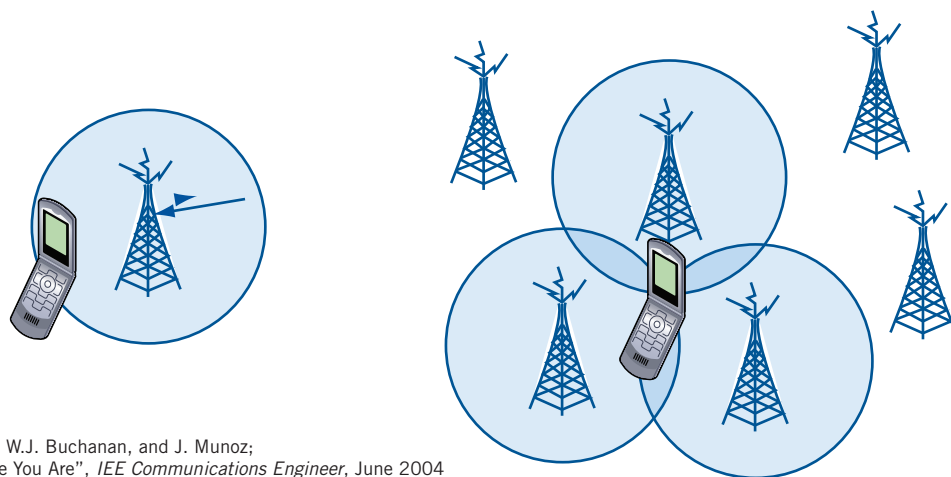
A benefit of the uplink TOA positioning mechanism is that it can be used with existing GSM handsets [3GPP TS 03.71].

Cell ID

Available in GSM networks is the "Cell ID" parameter. This value is present in the mobile handset's Subscriber Identity Module (SIM) card and the GSM network itself. The Cell ID value can be converted to a location estimate using details of mobile network cell coverage present in the SMLC.

The Cell ID value alone may not necessarily be an accurate way to determine the location of a particular mobile handset. In urban environments, the accuracy is typically around 1.24 mi. (2 km), although this can improve in city centers to around .3 mi. (500 m). Accuracy can be 3.1 mi. (5 km or worse) in suburban and rural environments which have fewer base stations [Raja].

To determine the Cell ID a mobile handset is currently located within, the SS7 "MAP Any Time Interrogation" service can be used, as described in [3GPP TS 09.02].



Source: K. Raja, W.J. Buchanan, and J. Munoz;
"We Know Where You Are", *IEE Communications Engineer*, June 2004

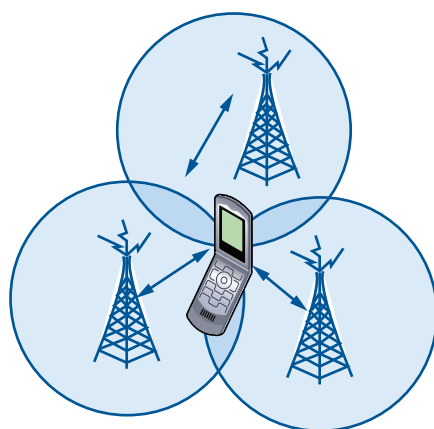
Figure 2. Uplink Time of Arrival (TOA)

Enhanced Observed Time Difference (E-OTD)

This positioning mechanism requires a handset to measure the arrival time of signals sent from three or more base stations.

- In “assisted” mode, the handset reports this information back to the SMLC. The SMLC uses these radio timing measurements to determine the handset location, as shown in Figure 3.
- In “handset-based” mode, the mobile handset itself makes use of timing measurement information to deduce the current location.

E-OTD requires modification to a standard GSM handset in order for radio timing measurements to be carried out, and for the mobile handset (in “handset-based” mode) to estimate the current location. Accuracy is typically <164 yds (<150 m) [Raja].



Source: K. Raja, W.J. Buchanan, and J. Munoz;
“We Know Where You Are”, *IEE Communications Engineer*, June 2004

Figure 3. Enhanced Observed Time Difference (E-OTD)

Global Positioning System (GPS) Assisted

This positioning mechanism is similar to the E-OTD technique just discussed, in that timing measurements are carried out based on signals received in order to determine mobile handset location. For “GPS assisted” positioning, these signals would come from a GPS satellite network, instead of GSM base station equipment, as shown in Figure 4.

“Assistance data” can be sent to a mobile handset from the GSM network as location information is required. Assistance data can take the form of a list of visible GPS satellites, from which a handset takes measurement information that aids location determination.

“GPS assisted” positioning requires a mobile handset that can receive signals from GPS satellites. Accuracy is typically <109 yds (<100 m) [Raja].

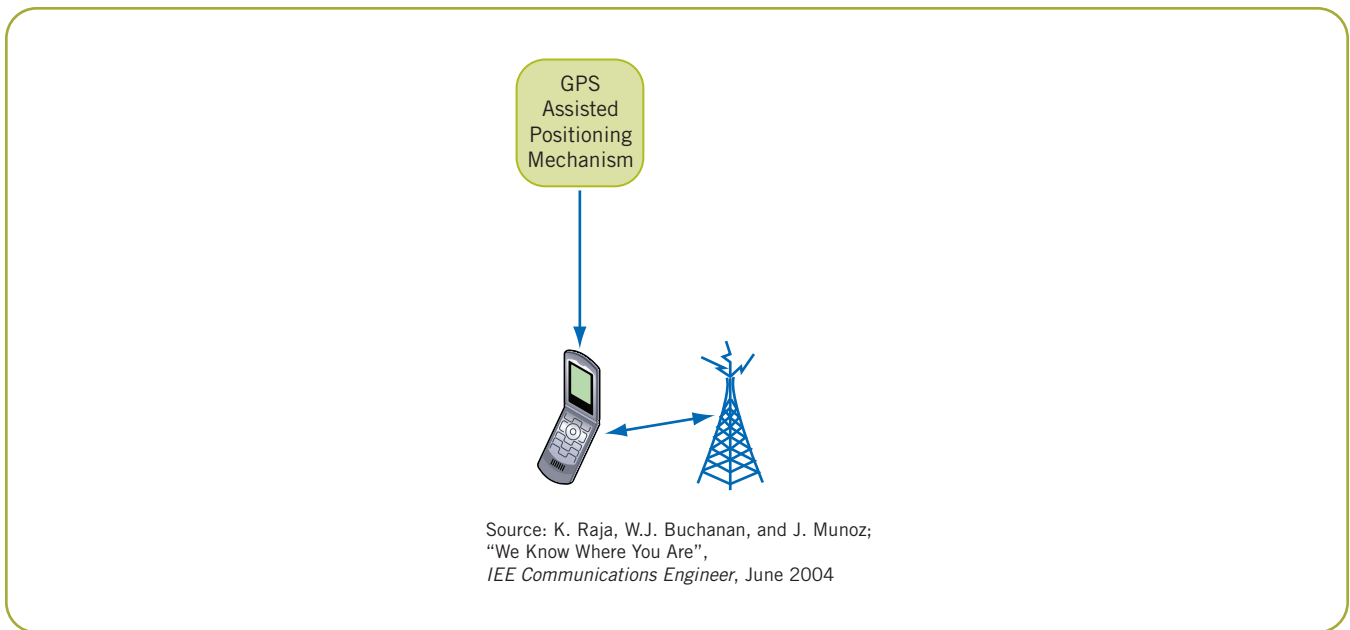


Figure 4. GPS Assisted

Creating LBS Applications

LBS applications can be developed without knowing the underlying positioning mechanism used within a specific mobile network. This simplifies the developer's task, allowing LBS applications to be deployed across mobile networks that support different LBS positioning mechanisms.

The LBS application developer requires connection to a mobile network. This can be obtained through negotiation with a mobile network provider and could be either an SS7 MTP-based connection or a SIGTRAN IP-based connection. When negotiating with a mobile network provider, the developer can ensure the mobile network supports a positioning mechanism as follows:

- Mobile handsets used by potential end customers of the LBS service can be supported. For example, the Uplink TOA positioning mechanism supports existing GSM handsets.
- Positioning information provided by the mobile network meets the accuracy requirements of the application.

LBS "Push" and "Pull" Service Models

LBS applications provide data based on the location of the mobile subscriber and can be segmented into "push" and "pull" models.

- The "Push" model is one in which information is proactively sent to subscribers. "Opt-in" mobile advertising is emerging as an effective way to send discounts, promotions, and contests to consumers who give their permission to receive such alerts.
- "Pull" services are used by subscribers to retrieve area information. Examples of this type of LBS being deployed include:
 - **Driving Directions** — Obtain directions from your location to your desired destination
 - **Maps** — View maps on your phone, detailing your current location
 - **City Guides** — Find local ATMs, restaurants, stores, and attractions

Example 1: Local Promotion Implementation ("Push")

Sending an advertisement for a local service/restaurant/promotion directly to a mobile subscriber's phone is one example of a "push" LBS. This application sends information to a mobile subscriber's handset advertising a specific service based on the mobile subscriber's current location. Figure 5 shows this graphically.

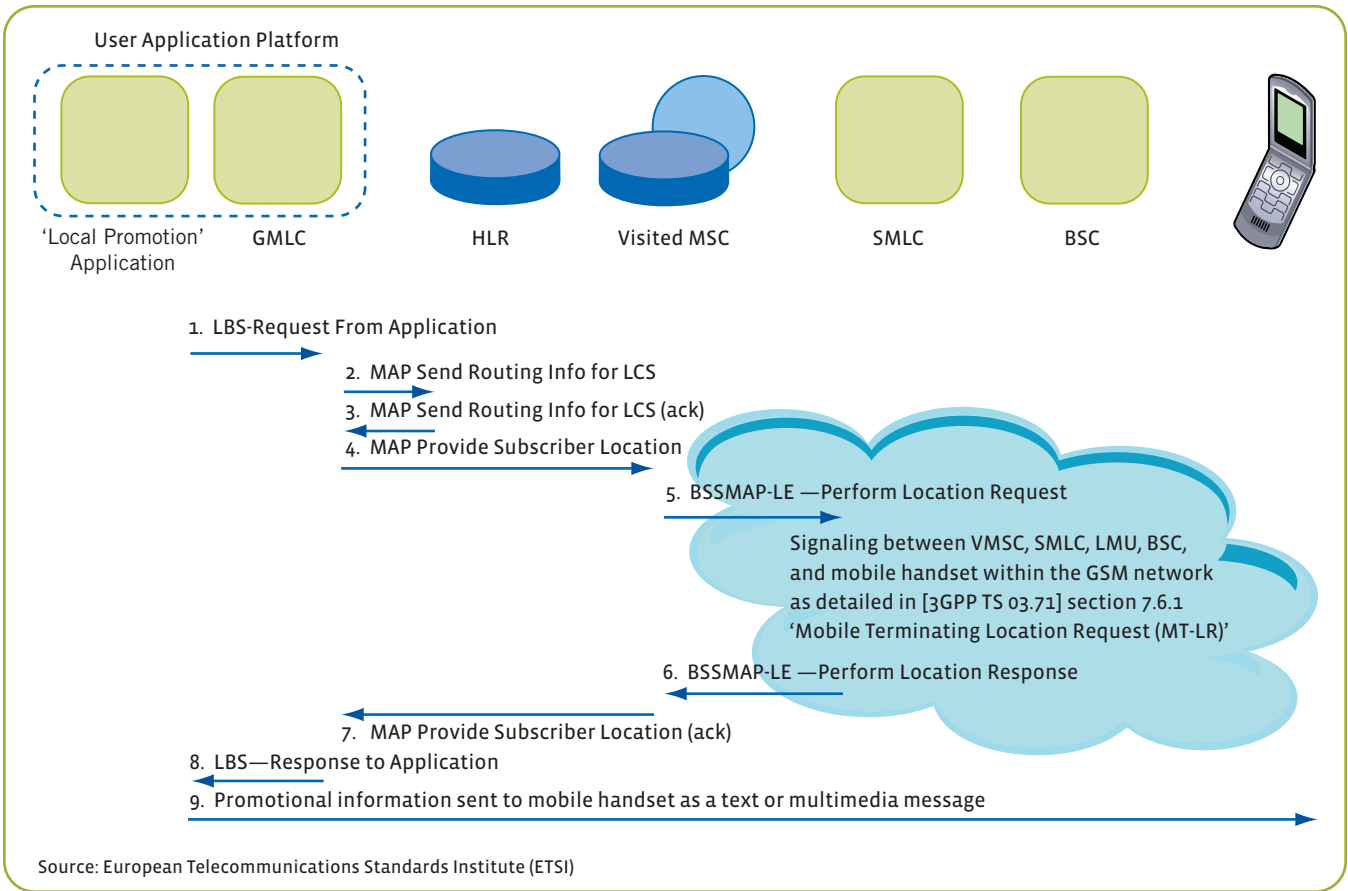


Figure 5. Request the Location of a Particular Mobile Handset

The application can request the location of a particular mobile handset, as shown in Figure 5. Signaling is used by this “push” application as follows:

1. The “local promotion” application sends a request to the GMLC to locate a particular mobile handset.
2. The application developer’s “GMLC node” queries the HLR to determine the MSC currently visited by the specified mobile handset. The MAP message, Send Routing Info for LCS, is used to request this information. A specific handset is identified by either the Mobile Subscriber ISDN number (MSISDN) or International Mobile Subscriber Identify (IMSI) number of the handset.
3. The visited MSC address is returned to the GMLC node using MAP Send Routing Info for LCS (ack).
4. The GMLC node requests the location of the specific mobile handset from the visited MSC using the MAP message Provide Subscriber Location.

5. Authentication and location determination are performed within the mobile network to determine the position of the specific mobile set, using one of the positioning mechanisms described in this application note.
6. Once the location has been determined, a Perform Location Response message is returned from SMLC to the VMSC.
7. VMSC returns the location information to the application developer’s GMLC node in the MAP message Provide Subscriber Location (ack) (see the shaded area). The received Provide Subscriber Location (ack) information includes details on the “location estimate” for the specific handset and the “age of the location estimate” information.
8. Location information will be passed to the “Local Promotion” application itself.
9. Once the “Local Promotion” application has details of the subscriber’s “location estimate”, the application could send a text or multimedia message to the subscriber’s handset, advertising local services of interest.

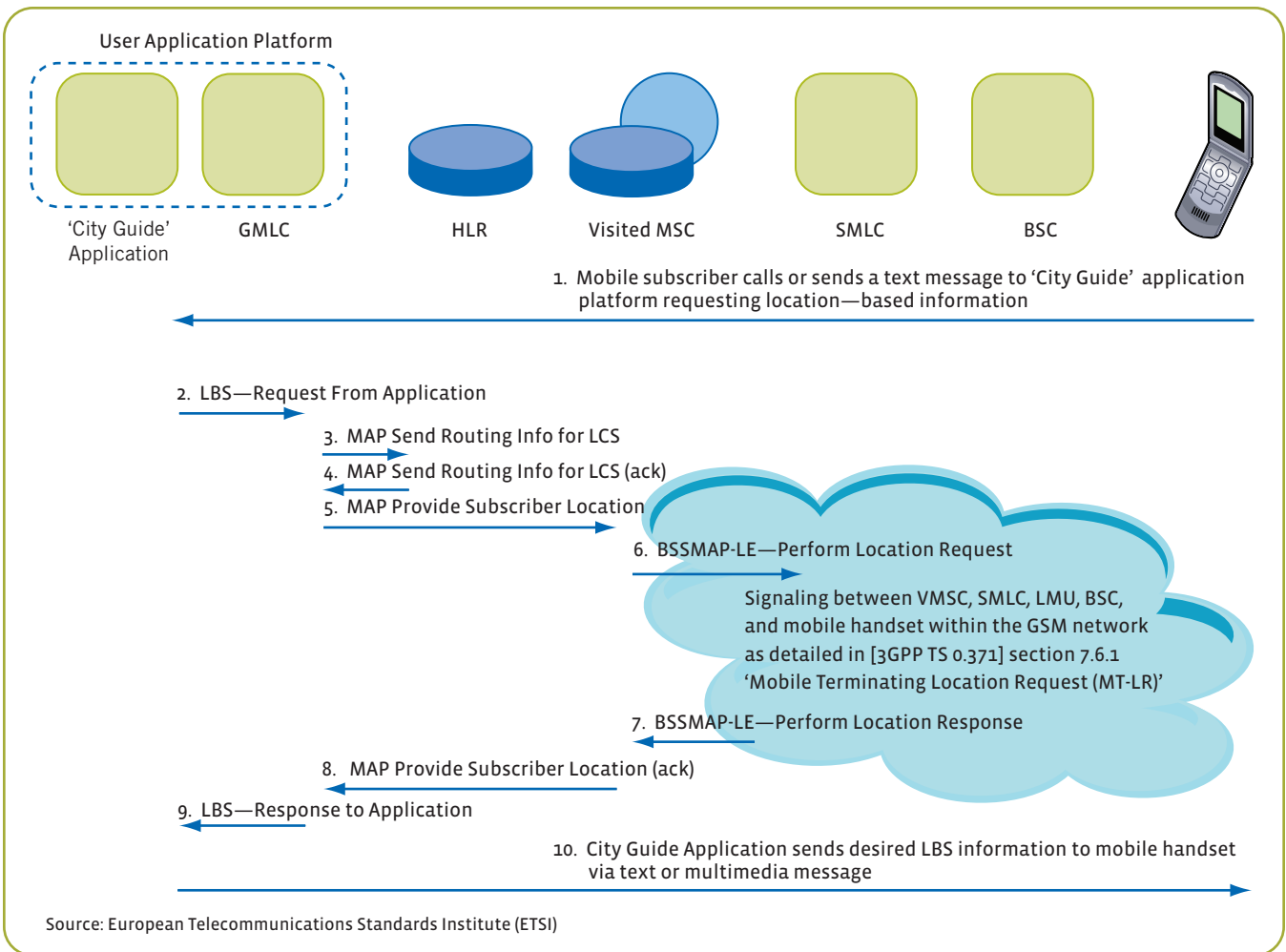


Figure 6: Mobile User Requests LBS “City Guide” Information

Example 2: City Guide Implementation (“Pull”)

Here, the mobile user requests information about the local area. Information is provided to the mobile users based on their current location (see Figure 6). The application developer can use a platform similar to that discussed in Example 1.

Signaling is used by this “pull” application as follows:

1. The mobile user requests information about the local area (possibly looking for a restaurant or a hotel) in one of two ways:
 - Calling the “City Guide” application platform and interacting with it via an Interactive Voice Response (IVR) system
 - Sending a text message requesting specific information

What location information does the Provide Subscriber Location (ack) message provide to the application developer?

As described in Examples 1 and 2, the user’s LBS application will be sent information detailing the “location estimate” of a particular mobile subscriber. The information received will include “geographical information,” as described in [3GPP TS 09.02].

“Geographical information” gives the location of a subscriber as a shape, such as an “ellipsoid point,” which can be used to detail a point on the Earth’s surface in terms of latitude and longitude. As described in [3GPP TS 09.02], one of several different shapes could be returned in the Provide Subscriber Location (ack) message “location estimate” information.

Details of shape definitions and descriptions (including shape encoding within MAP messages) are given in [3GPP TS 23.032].

The “age of location estimate” information is provided in terms of an integer, giving the number of minutes since the mobile handset was last contacted, as described in [3GPP TS 09.02].

2. The “City Guide” application sends a request to the GMLC implementation to locate a particular mobile handset.
3. The application developer’s “GMLC node” queries the HLR to determine the MSC currently visited by the specified mobile handset. The MAP message Send Routing Info for LCS is used to request this information. A specific handset is identified by either the MSISDN or IMSI number of the handset.
4. The visited MSC address is returned to the GMLC node using MAP Send Routing Info for LCS (ack).
5. The GMLC node requests the location of the specific mobile handset from the visited MSC using the MAP message Provide Subscriber Location.
6. Authentication and location determination are performed within the mobile network to determine the position of the specific mobile set, using one of the positioning mechanisms described in this application note.
7. Once the location has been determined, a Perform Location Response message is returned from SMLC to the VMSC.
8. The VMSC returns the location information to the application developer’s GMLC node in the MAP message Provide Subscriber Location (ack). The received Provide Subscriber Location (ack) information includes details on the “location estimate” for the specific handset and the “age of the location estimate” information.
9. Location information will be passed to the “City Guide” application itself.
10. Once the “City Guide” application platform has an estimate for the location of the mobile handset, specific LBS information can be supplied to the handset.

Information for System Design: Working with MAP Signaling

An implementation of the City Guide application platform just described is capable of carrying out the following steps:

- Receive Short Message Service (SMS) messages from mobile users requesting LBS information.
- Send MAP Send Routing Info for LCS messages and receive routing information.
- Send MAP Provide Subscriber Location messages (using routing information) and receive “location estimate” and “age of location estimate” information for a handset.
- Act on the location information received, to determine which LBS data is sent to the mobile user.
- Finally, send LBS data to the mobile user in an SMS message.

SMS and LBS services are provided by the MAP. MAP uses the services of Transaction Capabilities Application Part (TCAP) and Signaling Connection Control Part (SCCP), as shown in Figure 7.

The Dialogic® SS7 Protocols MAP Test Utility (MTU) demonstrates how to build an application that can send and receive MAP messages using the services of TCAP and SCCP. This could be a starting point to develop an application such as described in the “Example 1: Local Promotion Implementation” or “Example 2: City Guide Implementation” [MTU and MTR User Guide].

The MTU has been developed to handle SMS messages. This functionality can be used to provide LBS information to a mobile handset as described in step 9 of the “Local Promotion” service, or step 10 of the “City Guide” application, previously described.

Further development of the MTU source code (outside the scope of this application note [MTU and MTR User Guide]) would enable a developer’s application platform (acting as the GMLC-node) to send and receive MAP Send Routing Info for LCS and MAP Provide Subscriber Location messages.

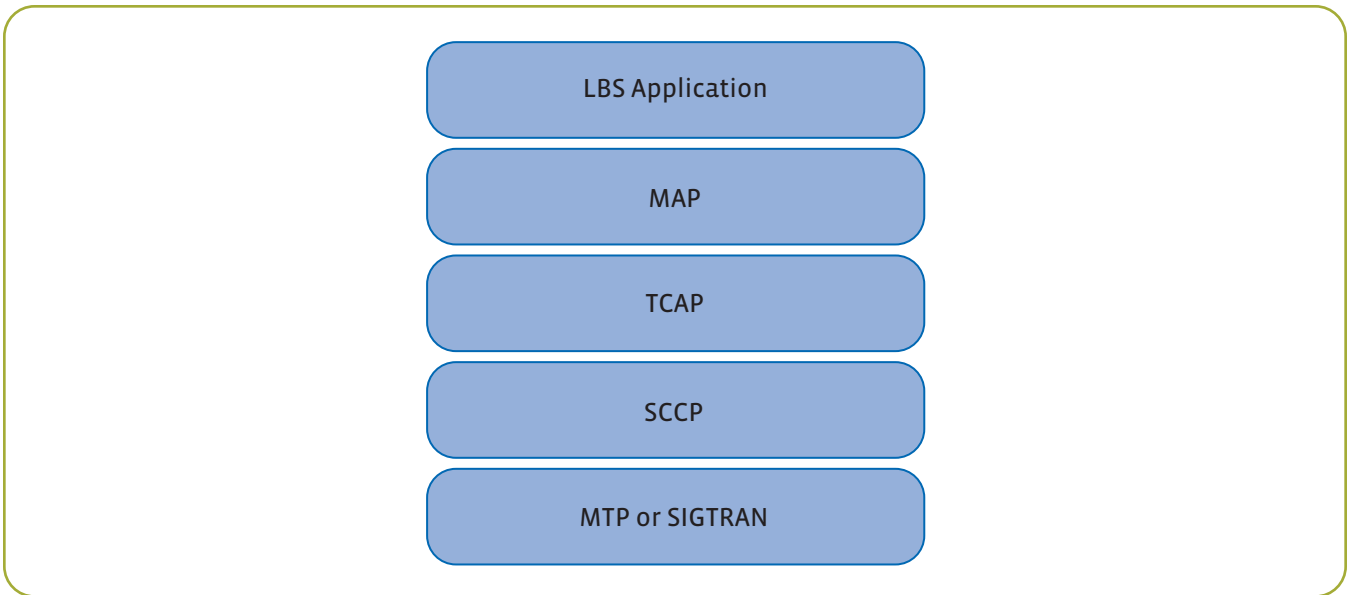


Figure 7. SS7 Protocol Layers for MAP Applications

Dialogic® Building Blocks for LBS

Dialogic® Signaling Distributed Architecture (SigDiA) enabled building blocks can be used to create the network elements for developing an LBS service.

As an example, Figure 8 shows dual Dialogic® SS7G22 Signaling Servers operating in Signaling Interface Unit (SIU) mode and SIU hosts acting as a Location Services Client and GMLC node, to create a User Application Platform.

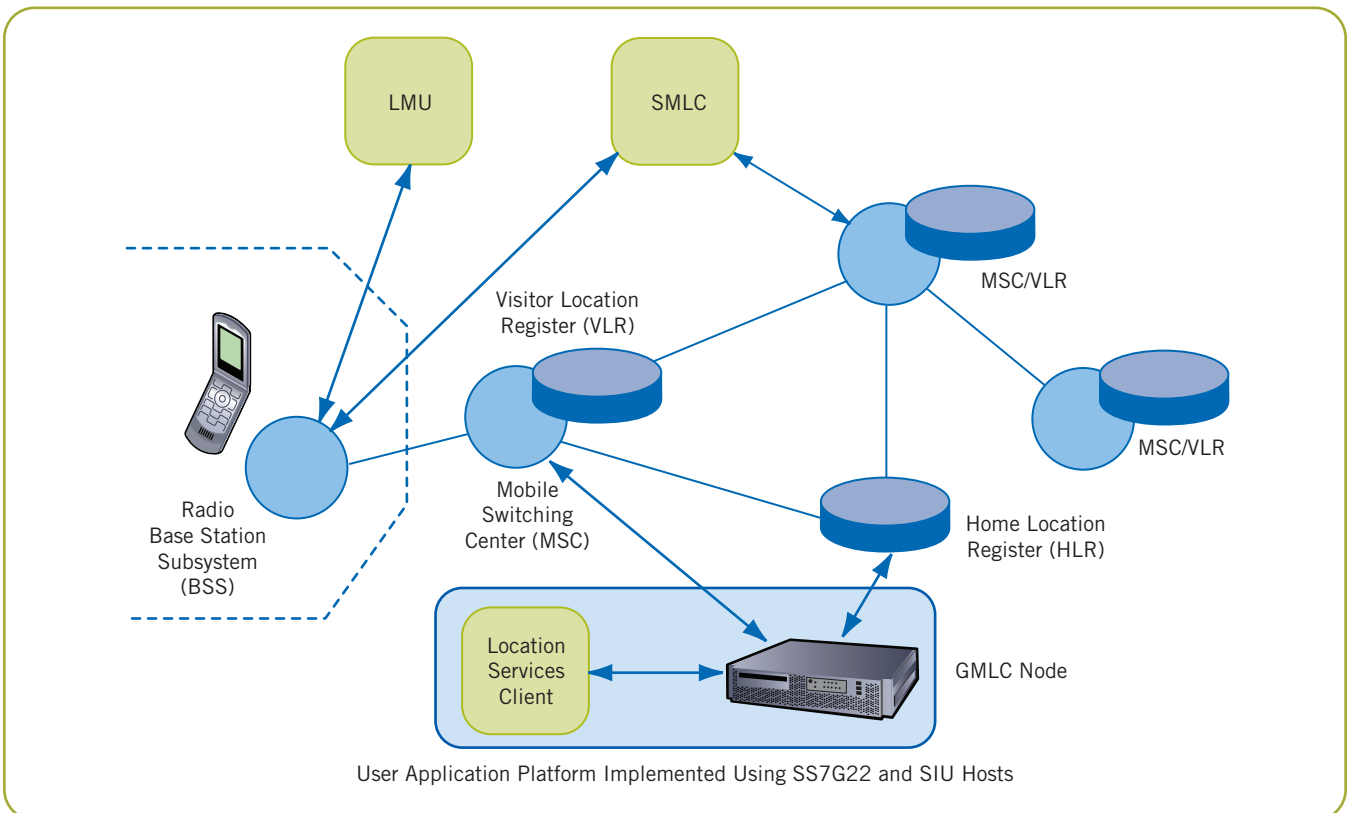


Figure 8. Implementing a User Application Platform with Dialogic® Signaling Building Blocks

For GSM MAP signaling, a number of building blocks are available, including:

- Dialogic® SS7AM1 SS7 Interface Board — http://www.dialogic.com/products/signalingip_ss7/components/Signaling_Boards_SS7AM1.htm
- Dialogic® Signaling Server with Signaling Gateway Option (Dialogic® SS7G21 and SS7G22 Signaling Servers) — http://www.dialogic.com/products/signalingip_ss7/components/signaling_servers_and_gateways.htm
- Dialogic® SS7HDC SS7 Interface Board (cPCI) — http://www.dialogic.com/products/signalingip_ss7/components/Signaling_Boards_SS7HDC.htm
- Dialogic® SS7HDP SS7 Interface Board (PCI) — http://www.dialogic.com/products/signalingip_ss7/components/Signaling_Boards_SS7HDP.htm
- Dialogic® SPCI4 SS7 Interface Board — http://www.dialogic.com/products/signalingip_ss7/components/Signaling_Boards_SPC.htm

Product choice depends on the level of integration, the expected transaction traffic, and the level of fault tolerance required, etc. The same Application Programming Interface (API) is used across the entire family of Dialogic® Signaling products, allowing easy migration from board-based to server-based solutions as service needs change. Further information on the range of Signaling building blocks is available on the web at <http://www.dialogic.com>

Summary

This application note presents an overview of network architecture and positioning mechanisms used by GSM LBS service providers.

It discusses how SS7 messaging is used for LBS services, providing information regarding signaling flows, and “push” and “pull” LBS service scenarios. The type of location information that can be provided by the GSM network is highlighted, including references that could be useful for system designers.

Finally, the application note looks at system design considerations, enabling LBS service designers to develop and deploy LBS applications with Dialogic® signaling products building blocks and protocol software.

References

[3GPP TS 03.71] Digital Cellular Telecommunications System (Phase 2+), Location Services (LBS), Functional Description, Stage 2, ETSI TS 101 724 V8.8.0 (2004-03); <http://webapp.etsi.org/key/queryform.asp>.

[3GPP TS 09.02] Digital Cellular Telecommunications System (Phase 2+), Mobile Application Part (MAP) Specification ETSI TS 100 974 V7.15.0 (2004-03); <http://webapp.etsi.org/key/queryform.asp>.

[3GPP TS 23.032] Universal Geographical Area Description (GAD) ETSI TS 123 032 V6.0.0 (2004-12); <http://webapp.etsi.org/key/queryform.asp>.

[MTU and MTR User Guide] *Dialogic® SS7 Protocols MAP Test Utility (MTU) and Responder (MTR) User Guide* — <http://www.dialogic.com/support/helpweb/signaling/software3.htm>.

[Raja] K. Raja, W.J. Buchanan, J. Munoz. “We Know Where You Are”, *IEE Communications Engineer* June/July 2004; <http://www.theiet.org/>.

Acronyms

3GPP	3rd Generation Partnership Project
API	Application Programming Interface
BSS	Base Station Subsystem
E-OTD	Enhanced Observed Time Difference
GMLC	Gateway Mobile Location Center
GPS assisted	Global Positioning System Assisted
HLR	Home Location Register
IMSI	International Mobile Subscriber Identity
IVR	Interactive Voice Response
LBS	Location-Based Service
LCS	Location Services (3GPP abbreviation)
LMU	Location Measurement Unit
MAP	Mobile Application Part
MSC	Mobile Switching Center
MSISDN	Mobile Subscriber ISDN Number
MTR	MAP Test Responder
MTU	MAP Test Utility
SCCP	Signaling Connection Control Part
SigDiA	Dialogic® Signaling Distributed Architecture
SIM	Subscriber Identity Module
SMLC	Serving Mobile Location Center
SMS	Short Message Service
TCAP	Transaction Capabilities Application Part
TOA	Time Of Arrival
VMSC	Visited MSC

For More Information

Dialogic® SS7 Protocols MAP Programmer's Manual —
<http://www.dialogic.com/support/helpweb/signaling/software3.htm>

Grow Revenue and Reduce Time to Market with Dialogic® Building Blocks: Location-Based Services —
<http://www.dialogic.com/goto/?9802>

Dialogic® Signaling building blocks —
http://www.dialogic.com/products/signalingip_ss7/components/signaling_software.htm

Dialogic® Signaling Products Software and Documentation —
<http://www.dialogic.com/support/helpweb/signaling/>

Dialogic® building blocks for high performance communications solutions —
<http://www.dialogic.com/products>

Dialogic® SS7 and Sigtran Signaling technical discussion forum —
<http://www.dialogic.com/forums/forums/forum-view.asp?fid=12>

North America “Enhanced 911 - Wireless Services” —
<http://www.fcc.gov/pshs/911/enhanced911/Welcome.html>

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Dialogic Corporation
9800 Cavendish Blvd., 5th floor
Montreal, Quebec
CANADA H4M 2V9

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