MAPS™ for LCS System

LoCation Services Simulation in 2G, 3G, and 4G
What is LoCation Service (LCS)?
Application of LCS

Public Safety Services
- Emergency Services, e.g. fire, police, ambulance, etc.
- Emergency Alert Services

Tracking Services
- Stolen phones, computers, other devices
- Vehicle tracking

Location Based Information Services
- Navigation
- City Sightseeing
- Finding nearest service, e.g. restaurant, bank, food store, etc.
- Mobile Yellow Pages
- Location Sensitive Internet

Up to date information
- Temperature, traffic services, etc.
LCS Network Architecture

2G GERAN
- LMU
- BSC
- SMSC
- A
- Gb
- Lb

3G UTRAN
- NodeB
- RNC
- SAS
- IuPS
- IuCS
- Lg
- LuPS
- LuCS

4G E-UTRAN
- eNodeB
- MME
- E-SMLC
- S1
- SLs
- Lg
- S1g

GMLC
- Lh
- SLh
- Le
- (IP)

External LCS Client

LCS – LoCation Services
SMLC – Serving Mobile Location Center
LMU – Location Measurement Unit
GMLC – Gateway Mobile Location Center
HLR – Home Location Register
MSC – Mobile Serving Center
SGSN – Serving GPRS Support Node
SAS – Stand Alone SMLC
E-SMLC – Enhanced - Serving Mobile Location Center
LCS Functional Entities

• **GMLC - Gateway Mobile Location Centre**
  - Central point of LCS architecture.
  - First node an external LCS client accesses in a GSM or UMTS network
  - Request routing information from the HLR (Home Location register) or HSS (Home Subscriber Server)
  - Receives final location estimates from the MSC, SGSN, or MME

• **SMLC/E-SMLC/SAS – Serving Mobile Location Server**
  - Server used for the locations calculation. It can calculate with information from LMU (where it is available), or measures of the network itself, such as TA (Timing Advance).

• **LMU – Location Measuring Unit**
  - Equipment required in each cell to enable the calculation of the OTDOA (based on the network location).
Standard Positioning Methods

- Cell-ID and TA Method
- Signal Strength Method
- Angle of Arrival Method (AoA)
- Time of Arrival Method (ToA)
- Time Difference of Arrival Method (TDoA)
- Enhanced Observed Time Difference (E-OTD)
- Assisted GPS Method (A-GPS)
Positioning Methods…

Cell-ID and TA Method – Network Based

- An area in which a MS moves freely without updating the location registration, can be estimated using the identification codes assigned to each active (communicating) MS.
- The identification codes are Cell Global Identity (CGI), such as Mobile Country Code (MCC), Mobile Network Code (MNC), Location Area Code (LAC) and Cell Identity (CI).
- Positioning error can be reduced by using Timing Advance (TA) which is a measure of the distance between the MS and the BTS.
Positioning Methods…

Received Signal Strength (RSS) Method – Network Based

• Distance from each BTS and the MS is approximated using the signal strength received by the MS
• MS is located at the intersection point of three circles centred by three BTSs
• Computed knowing the radius of the circles
Positioning Methods...

Angle of Arrival (AoA) Method – Network Based

- Uses the angle of the signals arriving to the MS from two BTSs
- Reduces the number of required assisting BTSs
- A slight error in measuring the angle, will cause a big error in MS positioning
Positioning Methods...

Time of Arrival Method (ToA) – Network Based

- Triangulation is used in the Time of Arrival (ToA) method to measure the propagation delay of transmitting to multiple BTSs.
- ToAs are measured using an additional hardware called Location Measurement Unit (LMU) installed in BTSs.
- All LMUs and the MS must share a common clock reference, i.e., strict synchronization is required.
Following timing parameters are calculated to compute the final accurate position.

- **Real Time Difference (RTD):** the synchronization difference between the BTSs
- **Geometric Time Difference (GTD):** the propagation time difference between the BTSs
- **Observed Time Difference (OTD):** Time difference measured by the mobile between the receptions of bursts transmitted from BTSs
Enhanced Observed Time Difference (E-OTD) – Handset Based

- Mobile listens to bursts sent from neighboring BTSs
- Mobile records burst arrival times
- Position is triangulated from:
  - Coordinates of BTSs
  - Arrival time of burst from each BTS
  - Timing differences between BTSs
Assisted GPS Method (A-GPS) – Handset Based

- Information from satellite is deployed for positioning
- GPS installed in the BTSs or the handsets
- GPS in handsets increases size and power consumption
- A-GPS methods are expensive, but they are accurate
- Requires only one BTS to find outdoor position
- Poor performance in dense urban areas or indoors
- Suggested to be combined with other methods
Standard Positioning Methods used in 2G/3G/4G

- The standard positioning methods supported within GERAN are:
  - Timing Advance
  - Enhanced Observed Time Difference (E-OTD) positioning mechanism
  - Uplink Time Difference of Arrival (U-TDOA) positioning mechanism
- The standard positioning methods supported within UTRAN are:
  - Cell ID based method
  - Network-assisted GPS methods (A-GPS)
  - Uplink Time Difference of Arrival (U-TDOA) positioning mechanism
- The standard positioning methods supported within E-UTRAN are:
  - Network-assisted GPS methods (A-GPS)
  - Downlink positioning – Received Signal Strength
  - Enhanced cell ID method – Hybrid Methods
## Comparison of Positioning Methods

<table>
<thead>
<tr>
<th>Positioning Methods</th>
<th>Accuracy (in meters)</th>
<th>Characteristics</th>
<th>Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell-ID &amp; TA</td>
<td>100-1500</td>
<td>Network Based</td>
<td>High</td>
</tr>
<tr>
<td>RSS</td>
<td>200-500</td>
<td>Network Based</td>
<td>High</td>
</tr>
<tr>
<td>AOA</td>
<td>100-200</td>
<td>Network Based</td>
<td>Good</td>
</tr>
<tr>
<td>TOA</td>
<td>50-200</td>
<td>Network Based</td>
<td>Good</td>
</tr>
<tr>
<td>TDOA</td>
<td>50-150</td>
<td>Network Based</td>
<td>Good</td>
</tr>
<tr>
<td>E-OTD</td>
<td>50-100</td>
<td>Handset Based</td>
<td>Good</td>
</tr>
<tr>
<td>A-GPS</td>
<td>5-30</td>
<td>Handset Based</td>
<td>Variable</td>
</tr>
</tbody>
</table>
MA - Message Automation
+
PS - Protocol Simulation
Supported Protocols / Interfaces

- **CAS, ISDN, MLPPP, SS7, MAP, CAMEL**
- **TDM**
- **4G**
  - LTE, Diameter
- **3G**
  - UMTS (IuH, IuCS, IuPS, GnGp)
  - GPRS
- **2G**
  - GSM (A, Abis)
  - GPRS
- **VoIP (Packet Network)**
  - SIP, MEGACO, MGCP, SIP-I, SIGTRAN (ISUP, ISDN), SKINNY

Common Protocol Emulation Framework

LTE Simulation

SS7 Simulation

SIP Simulation
Common Features

- Multi-protocol, Multi-interface Simulation
- Script based and protocol independent software architecture
- Auto generate and respond to signalling messages
- Traffic Handling Capabilities (requires additional license)
- Automated Bulk Call Generation / Stress Testing
- Easy script builder for quick testing to advance testing
- Customization of test configuration profiles
- Unlimited ability to customize the protocol fields and call control scenarios
IP variants of MAPS can be run on any modern Windows server.

A typical i7 platform will be able to handle ~2000 concurrent RTP sessions through a conventional server-grade NIC.

We also offer an HD (High Density) appliance which can deliver up to 20,000 concurrent RTP sessions per U of rack space.
Remote MAPS Controller

- Multi-node and multi-interface simulation from a single GUI
- Suitable for testing any core network, access network, and inter-operability functions
- Single Licensing Server controlling server and client licenses (no. of users)
- Unlimited number of remote client user can be defined at the server
- Admin privileges to control Testbed and access to configuration files for each remote client user
- Remote Client users has privileges to perform all other functions - call simulation, edit scripts/profiles, and view statistics
- Simultaneous traffic generation/reception at 100% on all servers
MAPS APIs

- API wraps our proprietary scripting language in standard languages familiar to the user:
  - Python
  - Java
  - VB Scripts
  - TCL
- Clients and Servers support a “Many-to-Many” relationship, making it very easy for users to develop complex test cases involving multiple signaling protocols.
Statistics and Reporting

Call Statistics and Graph

User Defined Statistics

- Active RTP Sessions: 1
- Completed RTP Sessions: 1
- Session with Zero Receive Traffic: 0
- MOS Score Stats:
  - Sessions with MOS: 5.0 - 6.0: 0 [0%]
  - Sessions with MOS: 6.0 - 7.0: 0 [0%]
  - Sessions with MOS: 7.0 - 8.0: 0 [0%]
  - Sessions with MOS: > 8.0: 0 [0%]
- Total RTP Packets Sent: 448035778
- Total RTP Packets Received: 448035835
- Packet Loss Stats:
  - Initial Packet Loss:
    - Sessions with Zero Packet Loss: 0 [0%]
    - Sessions with Packet Loss (%) ≤ 1%: 0 [0%]
    - Sessions with Packet Loss (%) > 1%: 0 [0%]
    - Sessions with Packet Loss (%) ≤ 2%: 0 [0%]
    - Sessions with Packet Loss (%) > 2%: 0 [0%]
- Packet Discarded Stats:
  - Total Packet Discarded:
    - Sessions with Zero Packet Discard: 0 [0%]
    - Sessions with Packet Discard (%) ≤ 1%: 0 [0%]
    - Sessions with Packet Discard (%) > 1%: 0 [0%]
    - Sessions with Packet Discard (%) ≤ 2%: 0 [0%]
    - Sessions with Packet Discard (%) > 2%: 0 [0%]
- Packet Duplication Stats:
  - Total Duplicate Packet:
    - Sessions with Zero Duplicate Packets: 0 [0%]
    - Sessions with Duplicate Packets (%) ≤ 1%: 0 [0%]
    - Sessions with Duplicate Packets (%) > 1%: 0 [0%]
    - Sessions with Duplicate Packets (%) ≤ 2%: 0 [0%]
    - Sessions with Duplicate Packets (%) > 2%: 0 [0%]
- Packet Out of Sequence Stats:
  - Total Out of Sequence Packet:
    - Sessions with Zero OOS Packets: 0 [0%]
    - Sessions with OOS Packets (%) ≤ 1%: 0 [0%]
    - Sessions with OOS Packets (%) > 1%: 0 [0%]
    - Sessions with OOS Packets (%) ≤ 2%: 0 [0%]
    - Sessions with OOS Packets (%) > 2%: 0 [0%]
- Jitter Stats:
  - Sessions with Jitter (%) ≤ 1: 0 [0%]
  - Sessions with Jitter (%) > 1: 0 [0%]
Questions?
GL’s MAPS™ in LCS Network
Supported Interfaces

• **Lb Interface**
  - MAPS™ supports Location Service (LCS) based GSM Lb interface
  - Between the BSC <-> SMLC is Lb interface

• **Lg, Lh Interfaces**
  - MAPS™ MAP IP supports Location Service (LCS) based Lh and Lg interfaces
  - Between the GMLC <-> HLR is Lh interface and between GMLC <-> MSC/SGSN is Lg interface

• **SLs Interface**
  - MAPS™ supports Location Service (LCS) based LTE SLs interface
  - Between the MME <-> SMLC is SLs interface

• **SLh, SLg Interfaces**
  - MAPS™ Diameter supports Location Service (LCS) based SLh and SLg interfaces
  - Between the GMLC <-> HSS is SLh interface and between GMLC <-> MME is SLg interface
MAPS™ supports simulation of different Positioning methods and Position Estimation of a Mobile Stations (MS) in universal coordinates.

• Location estimate parameters such as Type of Shape and coordinates can be input through conventional user profiles or can be fetched from a CSV file.

• Co-ordinates indicate different position of MS at different intervals of time.

• Report is sent either periodically at specified time duration or at once when requested.
LCS in 2G Architecture

LCS – LoCation Services
SMLC – Serving Mobile Location Center
LMU – Location Measurement Unit
GMLC – Gateway Mobile Location Center
HLR – Home Location Register
MSC – Mobile Serving Center
SGSN – Serving GPRS Support Node

MAPS™ MAPIP Emulator (Lg, and Lh)
MAPS™ Lb Emulator
2G - Procedures

1. Location Service Request
2. Identify Subscriber
3. Route to Identified Subscriber
4. Forward to BSC
5. Forward to SMLC
6. Request to Calculate
7. Request forwarded to MS/LMU
8. Positioning Parameters are sent to BSC
9. Request to Calculate
10. Subscriber Location Report to BSC
11. Forward Report to MSC
12. Forward Report to GMLC
13. Forward Report to Client
2G - Typical Call Flow

LCS Client → LCS Service Request

MSC

HLR → MAP Send Routing
Info for LCS

MAP Provide Subscriber Location

BSS

SMLC → LCS Location Notification

LCS Location Notification Return Result

BSSAP Perform Location Request

BSSMAP-LE Perform Location Request

BSSMAP-LE Connection Oriented Info
(BSSLAP MS Command – RRLP message)

RRC LCS DL Info
(RRLP message)

RRC LCS UL Info
(RRLP message)

BSSMAP-LE Connection Oriented Info
(BSSLAP MS Response – RRLP message)

BSSMAP-LE Perform Location Response

MAP Provide Subscriber Location Ack

LCS Service Response

BSSAP Perform Location Response

MS/UE
LCS in 3G Architecture

LCS – LoCation Services
SAS – Stand Alone SMLC
(SMLC – Serving Mobile Location Center)
GMLC – Gateway Mobile Location Center
HLR – Home Location Register
MSC – Mobile Serving Center
SGSN - Serving GPRS Support Node
RNC - Radio Network Controller

External LCS Client

MAPSTM MAPIP Emulator (Lg, and Lh)
MAPSTM Iupc Emulator
3G - Procedures

(1) – Location Service Request
(2) - Identify Subscriber
(3) - Route to Identified Subscriber
(4) - Forward to RNC
(5) - Forward to SAS
(6) - Response from SAS
(7) - Request forwarded to MS

(8) – Positioning Parameters are sent to RNC
(9) – Request to Calculate
(10) – Subscriber Location Report to RNC
(11) – Forward Report to MSC
(12) - Forward Report to GMLC
(13) – Forward Report to Client
LCS in 4G Architecture

LCS – LoCation Services
E - SMLC – Enhanced Serving Mobile Location Center
GMLC – Gateway Mobile Location Center
HSS - Home Subscriber Server
MME- Mobility Management Entity
SGSN - Serving GPRS Support Node
PDN GW - Packet Data Network Gateway
SGW - Signaling Gateway

MAPS™ Diameter Emulator (SLg, and SLh)
MAPS™ LTE SLs Emulator
4G - Procedures

(1) – Location Service Request
(2) - Identify Subscriber
(3) - Route to Identified Subscriber
(4) - Forward to E-SMLC
(5) - Response from E-SMLC
(6) - Request to Calculate
(7) - Positioning Parameters are sent to MME
(8) – Request to Calculate
(9) – Subscriber Location Report to MME
(10) - Forward Report to GMLC
(11) – Forward Report to Client
Thank You