Network Assisted GPS (N-GPS) Positioning in WiMAX/16m

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Venue:

IEEE Session #57, Kobe.

Base Contributions:

None

Re: Call for Contributions on Project 802.16m System Description Document (SDD): MAC aspects of enhanced LBS

Purpose: Discussion and Approval

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Network Assisted GPS (N-GPS) Positioning in WiMAX/16m

Shu Wang, Ki-Dong Lee, Li-Hsiang Sun, Sang G. Kim and Byung K. Yi

LG Electronics Mobile Research USA

Outline

- LBS Requirement in 802.16m SRD
- Introduction to LBS
  - FCC E911 and EU E112
  - Existing Positioning Technology Comparison
- GPS Positioning Principle and Error Sources
- A Snapshot of Assisted GPS Positioning
- GPS Positioning Assistance in WiMAX: Broadcast and/or Unicast Assistance
  - The Inadequate GPS Assistance in 16e: GPS Time/Frequency TLV
  - Enhancement I: Enhanced GPS TLV
  - Enhancement II: Enhanced LBS Management
  - Enhancement III: GPS Assistance Zone
  - Other Assistance
  - Performance
- Proposed ToC
- Proposed SDD Text

Positioning Requirements in 802.16m SRD

- ***7.6 Location-based services performance***
  - IEEE 802.16m systems (this may include MS, BS, or both depending on the solution) should provide support for LBS. IEEE 802.16m systems should satisfy the requirements in Table 15.

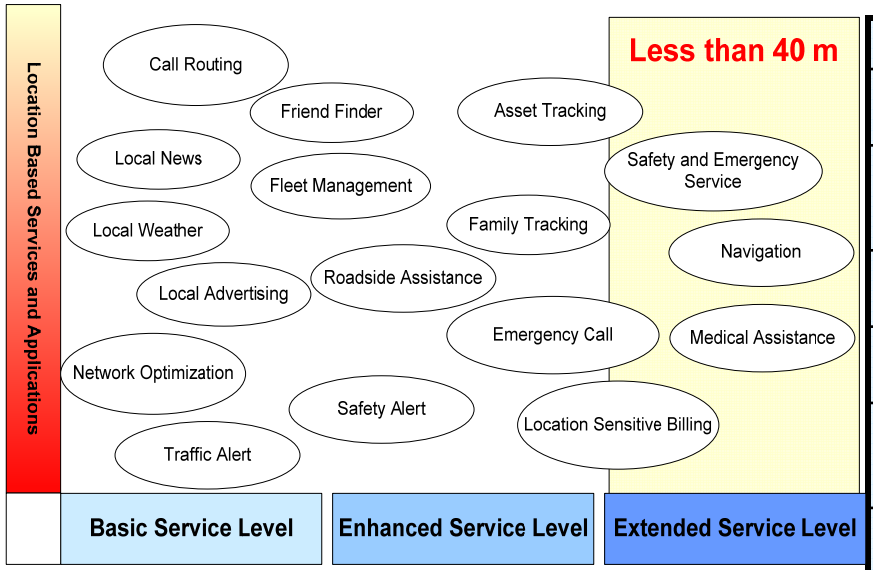
Feature	Requirement	Comments
Location determination latency	< 30 s	
Handset-based position accuracy (in meters)	50 meter (67%-tile of the CDF of the position accuracy) 150 meter (95%-tile of the CDF of the position accuracy)	Need to meet E911 Phase II Requirements
Network-based position accuracy (in meters)	100 meter (67%-tile of the CDF of the position accuracy) 300 meter (95%-tile of the CDF of the position accuracy)	

Table 15–Location-based service requirements

Introduction (1/2): E911 and E112

- **FCC Enhanced 911**
  - **Phase I:** Within six months of a request by a Public Safety Answer Point (PSAP), the carrier shall provide PSAPs with the telephone number and the cell site location for this 911 call.
  - **Phase II:** Within six months of a request by a PSAP, more precise location information, such as the latitude and longitude of the caller, shall be provided.
    - For network-based solutions, 100 meters for 67%; 300 meters for 95%.
    - For handset-assisted solutions, 50 meters for 67%; 150 meters for 95%.
  - **Phase II Compliance Status:** In August 2007, FCC fined several carriers $2.8M for failing to meet the mandate (December 2005) to provide E911 service to 95 percent of their networks.
- **EU Location-Enhanced 112**
  - In 2000, the EU launched activities for enhanced 112 (E-112) and CGALIES (the Coordination Group on Access to Location Information for Emergency Services) is initiated.
  - In September 2002, an EMTEL (Emergency Telecommunication) ad hoc group under the ETSI OCG (Operational Co-ordination Group) was set up to look at standardization requirements.
  - In July 2003, the EU issued a Recommendation for the Europe-wide implementation of the location-enhanced 112.
- **Mission Unaccomplished.**
  - It is not a easy job to completely satisfy the mandates alone.
  - LBS is also believed to be a key feature of next generation mobile standards including 16m.
  - It is important for 16m to provide a simple and efficient scheme assisting GPS-based positioning.
    - GPS-based positioning is known to be one of the most reliable positioning schemes with the best coverage and highest accuracy.
    - With close to 1.18 billion mobile handsets sold in 2007 and an expected 1.8 billion in 2012, close to 30% of existing worldwide mobiles are GPS-capable in 2008. This number is increasing every year and predicted to more than 35% in 2012 by Texas Instrument and gpsWorld.
    - ABI Research forecasts that global revenue from location-based services will hit $13.3 billion by 2013, compared with $515 million in 2007.

Introduction (2/2): Existing Technologies Comparison

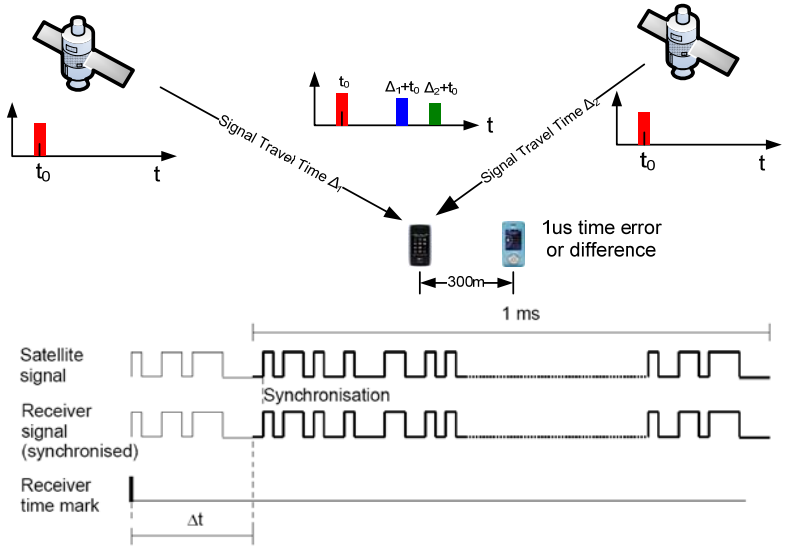


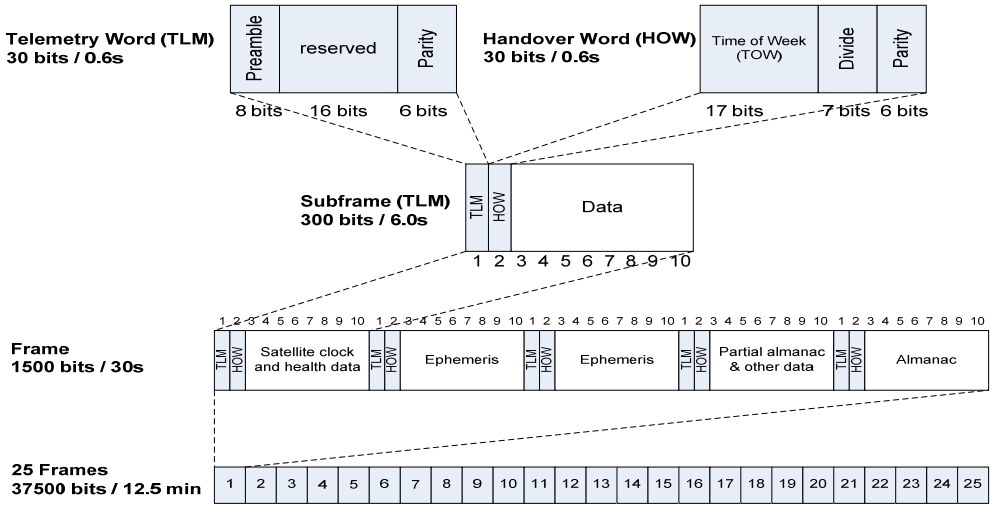
*The rough accuracy data are compiled from the claims of various technology providers.

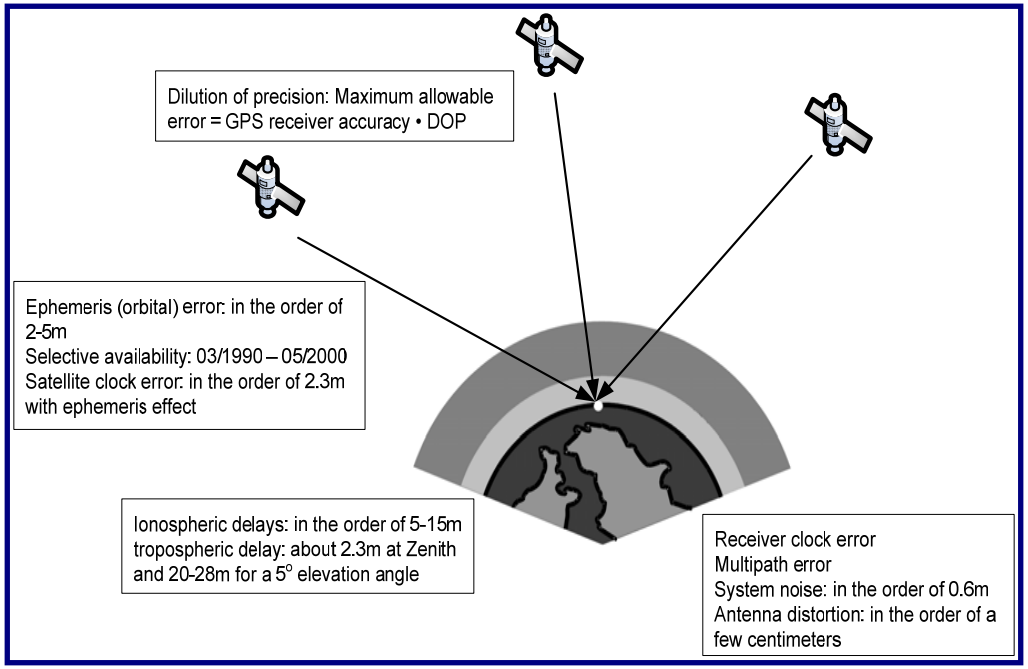
	Attributes	Network	Handset	Performance*
Cell ID	**obtains Cell ID based on pilot measurements**	All	All	100m-3km. Depends on cell size and density
Cell ID + TA	**combines Cell ID with time advance**	UMTS	All	Default is 500m. Depends on bandwidth & system resolutions.
EFLT	**measures the forward link pilot timing.**	CDMA	All	250-350m
AOA	**measures the angle of arrival by base stations**	All	All	100-200m
EOTD	**measures time difference by network and mobiles.**	UMTS	upgrade	50-200m
AFLT	**measures the forward link pilot timing.**	CDMA	upgrade	50-200m
U-TDOA	**Network measures the timing difference**	All	All	50 – 100 m.
GPS/A-GPS	**utilize the GPS receivers embedded in the handsets and network.**	**All**	**upgrade**	**5 - 30m**

- Applications usually require different service levels. [Source: Location Interoperability Forum (LIF), now a part of Open Mobile Alliance (OMA)]
  - Basic service level: 400-1500m
  - Enhanced service level: 40-150m
  - **Extended service level: less than 40m.**

The Principles of GPS Positioning

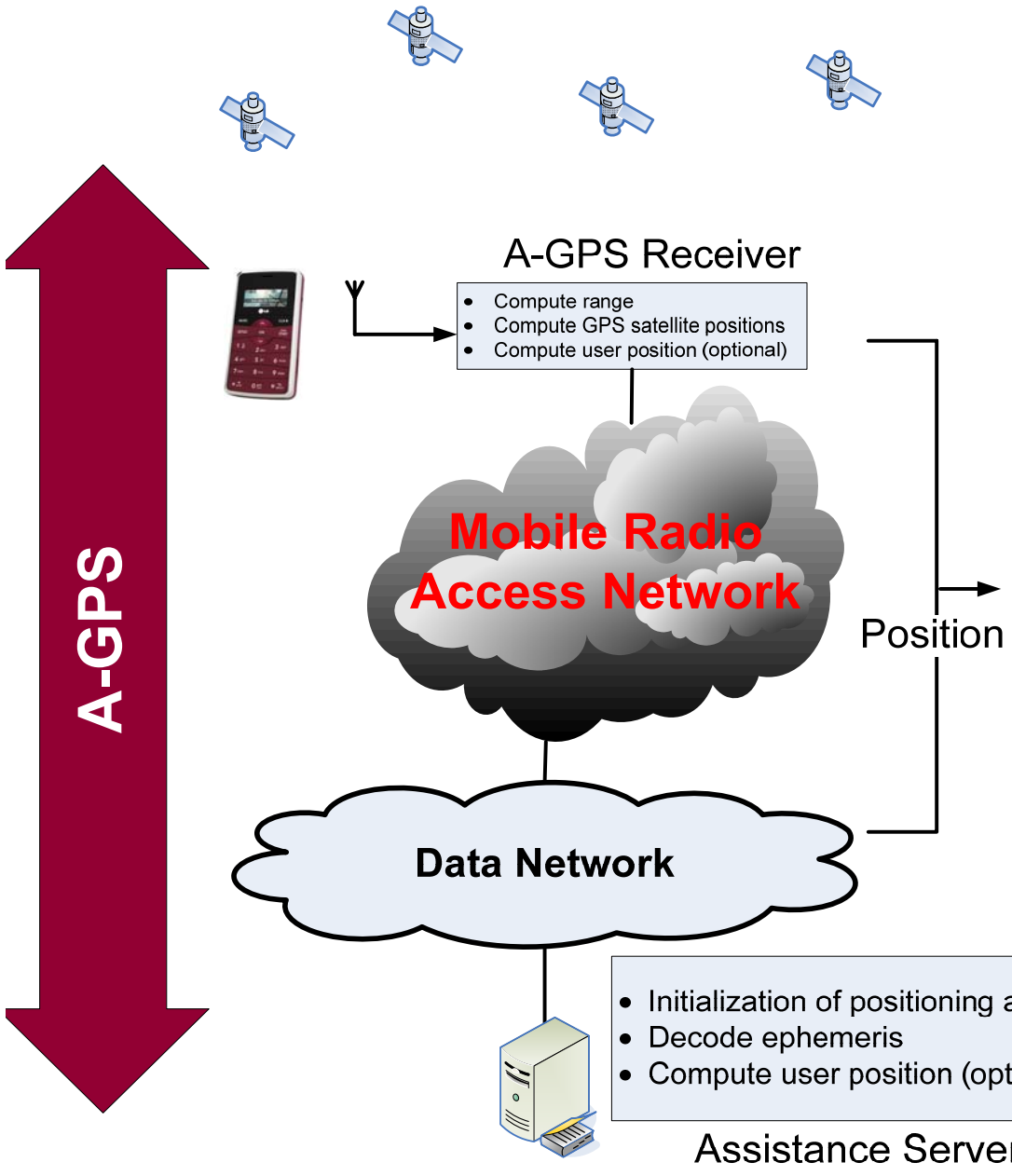




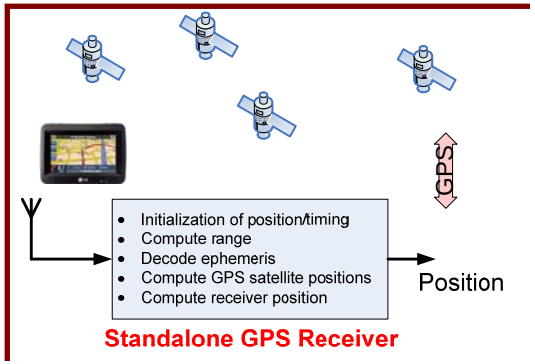


- **GPS Messages**
  - **TLM – Telemetry**: 30 bits, sent at the beginning of each frame.
    - It is used for data synchronization and satellite maintenance.
    - They are usually constant for any one satellite for a long period of time.
  - **HOW – Handover Word**: 30 bits, sent after TLM.
    - It indicates the time at the beginning of the next subframe.
    - It also contains a sub-frame ID, some flags and parity bits.
  - **Ephemeris**: It is sent in each frame by each satellite.
    - It may take the GPS receiver up to 30 seconds to acquire Ephemeris.
  - **Almanac**: It is spread out over all 25 frames of the message.
    - For receiving the complete Almanac, the GPS receiver may need about 12.5 minutes.

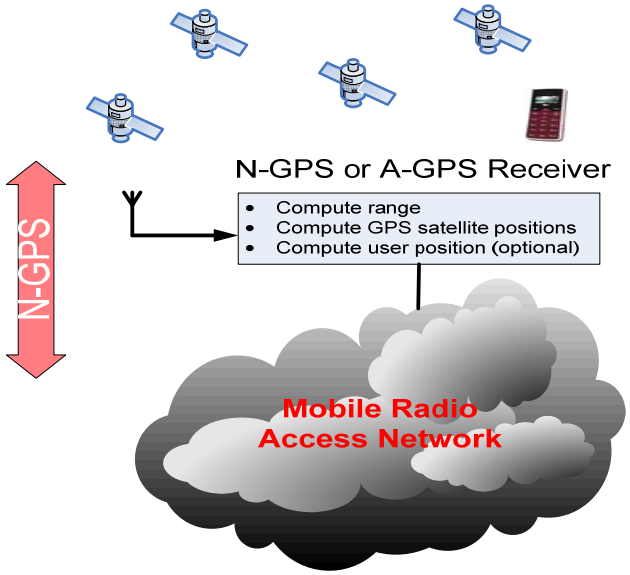
Assisted GPS Positioning

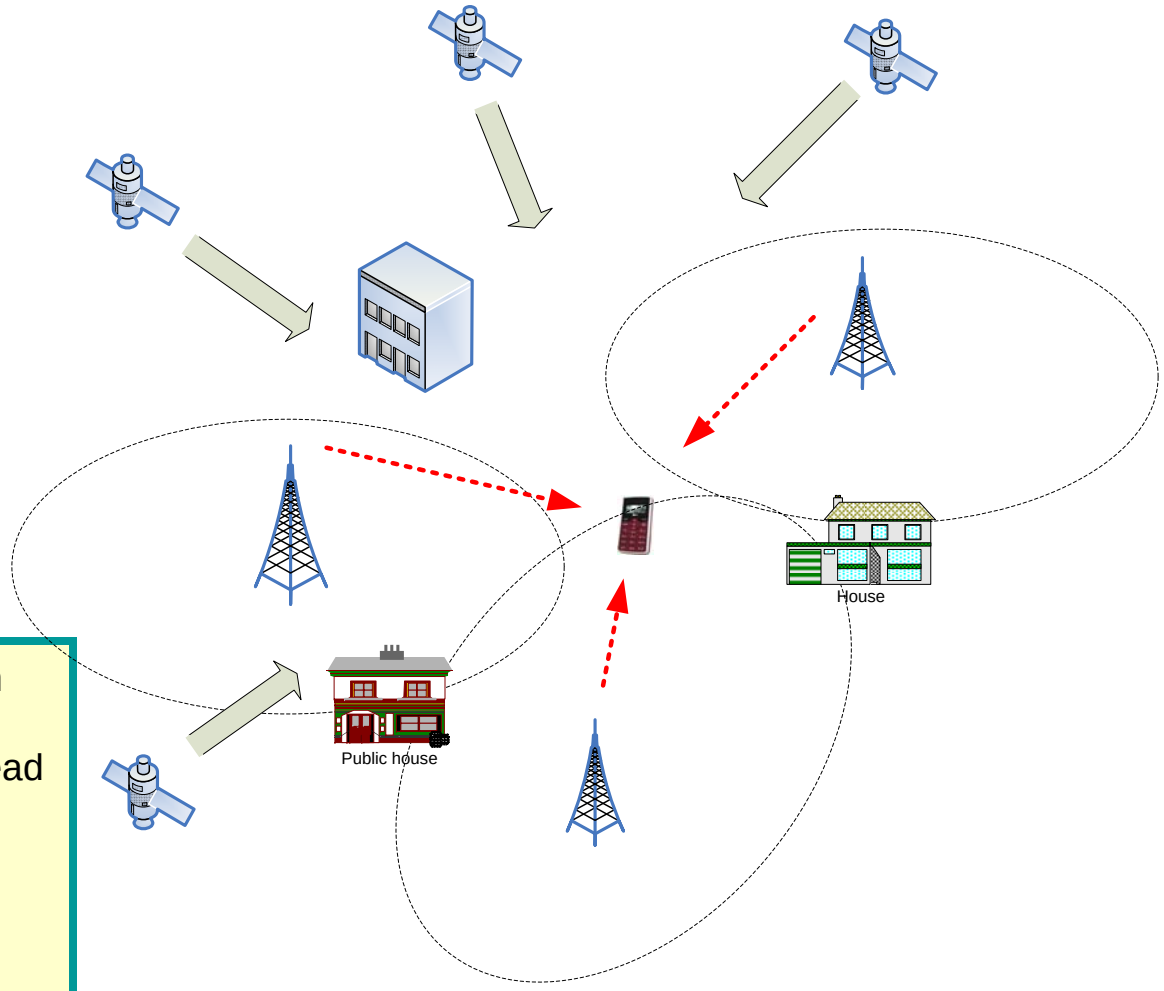


- A-GPS with assistance server were developed to enhance the positioning performance of a GPS receiver and satisfy FCC's E911 mandate.
  - It was firstly come out by Bell Labs before the 1996 FCC ruling.
- Assistance server can increase the capability of a stand-alone receiver.
  - It can roughly locate mobiles along by itself.
  - It can supply more GPS orbital data to the mobile.
  - It has better knowledge of atmosphere conditions and other errors as well as better augmentation capability.
- With assistance server, A-GPS help improve positioning in terms of
  - Location accuracy: the positioning error.
  - Yield: the positioning success rate.
  - Time to fix: the time for positioning.
  - Battery consumption: power consumption for positioning.
  - Mobile device cost.



Network-Assisted GPS: It is the network!





- Key GPS assistance is provided through control plan instead of user plan.
- No additional data channel setup overhead required.
- No additional layer-3 authentication or access control required.
- No roaming issue.
- More reliable than layer-3 A-GPS approaches.
- More efficient if the assistance data is periodically broadcasted.
- It is fully compatiable with most existing A-GPS receivers.

•Each capable base station tracks GPS messages by its own. No addition overhead to the backbone.

Comparison of GPS, N-GPS and A-GPS

Feature	GPS	N-GPS	A-GPS
Accuracy	Good	Better	Best
Yield	Good	Better	Best
TTFF	Slow	Fast or Faster due to less assistance overhead	Faster
Additional Carrier Investment	No	**No**	**Yes**
Required Network Resource	No additional resource needed	**Only Control Channel**	Control Channel Required
		No Traffic Channel	**L1/ L3 Traffic Channel Required**
Access Control	None	**Only Mobile Network Access Control**	Mobile Network Access Control
			Additional location service access control is required
Roaming Issues	No	**No**	**Complicate, especially between carriers**
Protocols	Open	**Open**	Propriety/Standard

The Inadequate GPS Assistance in 16e

Field	Size	Description
GPS Second	12 bits	GPS second, modulo 2048
GPS Second fraction	28 bits	GPS second fraction
GPS time accuracy	8 bits	GPS Time Accuracy For unsigned integer values 0x00-0x3F: $\log_2$(Time error in pico seconds). For unknown accuracy in time error, 0xFF. Values 0x40-0xFE not allowed.

Name	Type	Length (bytes)	Value
Frequency information	5	1	BS transmit frequency accuracy in ppm. For values in range 0x00-0xFE, frequency root mean square error is (value+1)*0.01 ppm. For value 0xff, the MS shall interpret this as max frequency accuracy uncertainty for that profile, see subclause 12.

- The GPS Time TLV informs the receiving MS of the precise time at which the BS's First Frame of the current epoch has been transmitted, which the MS may use to calibrate its own internal clock in reference to the GPS time standard.
  - The GPS Time TLV is used if the BS's frame time is synchronized with the GPS clock. This may be particularly valuable for determining GPS satellite signal search windows in mobiles equipped to detect GPS satellites.
  - GPS second and second fraction allow the MS to use DL Frame arrival times as timing signals aligned with GPS time.
  - GPS Time Accuracy aids the MS in estimating how much error with respect to GPS time the BS may have when using this calibration.
- The GPS Frequency TLV shall be used to provide the frequency accuracy information.
  - BS transmit frequency accuracy in ppm.
  - For values in range 0x00-0xFE, frequency root mean square error is (value+1)*0.01 ppm.
  - For value 0xff, the MS shall interpret this as max frequency accuracy uncertainty for that profile.

•In 16e, some GPS assistance is available. However, it lacks some key GPS data, especially the GPS Almanac data, for a A-GPS receiver to quickly and successfully perform the important first fix.

Enhancement (1/3): Enhanced GPS TLV

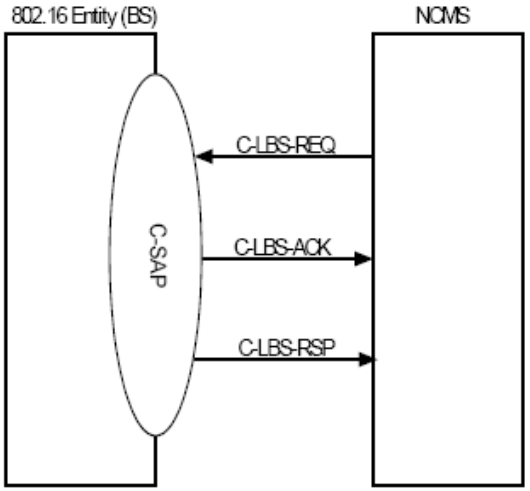
Name	Type	Length (Byte)	Value
GPS Almanac TLV	**XXX**	**Variable**	**GPS Almanac Data**
Field Bit-Map	XXX.0	2	It signaling which field of GPS Almanac is available.
GPS Satellite ID	XXX.1	1	PRN of the SVN, Range: 0 to 32; Accuracy: I
Satellite Health	XXX.2	1	000=usable; Range: 0 to 63; Accuracy: None
Eccentricity	XXX.3	3	This shows the amount of the orbit deviation from circular (orbit). It is the distance between the foci divided by the length of the semi-major axis (our orbits are very circular). Range: 0.0 to 0.03; Accuracy: 4.7E-7
Time of Applicability (s)	XXX.4	3	The number of seconds in the orbit when the almanac was generated. Kind of a time tag. Range: 0 to 602112; Accuracy: 1
Orbital Inclination (rad)	XXX.5	3	The angle to which the SV orbit meets the equator (GPS is at approx. 55 degrees). Roughly, the SV's orbit will not rise above approx. 55 degrees latitude. The number is part of an equation: #= pi/180 = the true inclination Range: -9.999999E-2 to +9.999999E-2; Accuracy: 1.91E-6
Rate of Right Ascen (r/s)	XXX.6	4	Rate of change in the measurement of the angle of right ascension as defined in the Right Ascension mnemonic. Range: -9.999999E-7 to +9.999999E-7; Accuracy: 3.6E- 12
SQRT(A) (m1/2)	XXX.7	2	This is defined as the measurement from the center of the orbit to either the point of apogee or the point of perigee. Range: 79.0 to 9999.99999; Accuracy: 4.8E-4

Enhancement (1/3): Enhanced GPS TLV (Con'd)

Name	Type	Length (Byte)	Value
Right Ascen at Week(rad)	XXX.8	3	Geograpic Longitude of the Asending Node of the Orbit Plane at the Weekly Epoch Range: -9.999999E-7 to +9.999999E-7; Accuracy: 3.6E- 12
Argument of Perigee(rad)	XXX.9	3	An angular measurement along the orbital path measured from the ascending node to the point of perigee, measured in the direction of the SV's motion. Range: -1.0 to +1.0; Accuracy: I.lE-7
Mean Anom(rad)	XXX.10	3	Angle (arc) traveled past the longitude of ascending node (value= 0-180 degrees or 0-negative 180 degrees). If the value exceeds 180 degrees, subtract 360 degrees to find the mean anomaly. When the SV has passed perigee and heading towards apogee, the mean anomaly is positive. After the point of apogee, the mean anomaly value will be negative to the point of perigee. Range: -1.0 to +1.0; Accuracy: 1.1E-7
Af0(s)	XXX.11	3	SV clock bias in seconds Range: -9.9999E-4 to +9.9999E-4; Accuracy: 9.5E-7
Af1(s/s)	XXX.12	3	SV clock Drift in seconds per seconds Range: -9.9999E-9 to +9.9999E-9; Accuracy: 3.6E- 12
GPS Week Number:	XXX.13	2	GPS week (0000-1023), every 7 days since 22 Aug 1999 Range: 0 to 1023; Accuracy: 1
Reserved	XXX.14 –XXX.16	N/A	N/A

- The including of the field, "Field Bit-Map", is for providing a mechanism for delivering only necessary Almanac data fields.
  - The length of "Field Bit-Map" is 2 bytes and 16 bits.
  - Each bit is mapped to each Almanac data field. For example, the 13th MSB of "Field Bit-Map" is mapped to XXX.13, GPS Week Number.
  - If the bit field is"0", it means this field is not included. If it is "1", it is included in the delivery.
- Reference: http://www.navcen.uscg.gov/GPS/gpssem.htm

Enhancement (2/3): Enhanced LBS Management

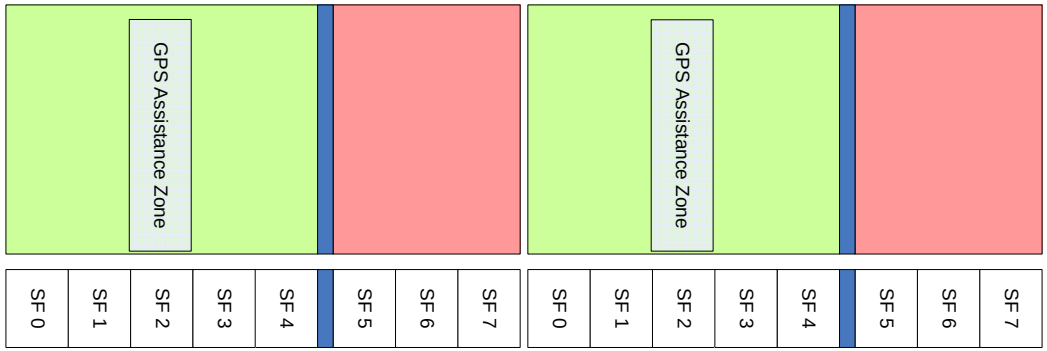


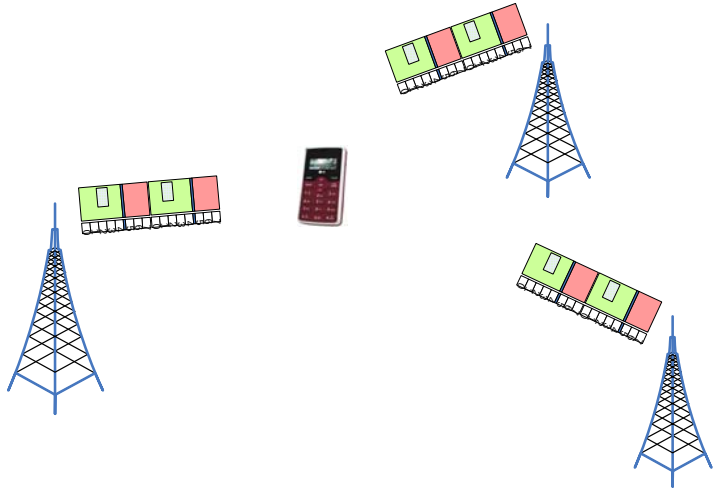
- **C-LBS-REQ** (
  - Operation_Type: Get,
  - Destination: BS,
  - Attribute_List:
    - MS MAC Address,
    - LBS Parameter Types

)
- **C-LBS-RSP** (
  - Operation_Type: Get,
  - Destination: NCMS,
  - Attribute_List:
    - MS MAC Address,
    - Requested LBS Parameters[]
      - BSID,
      - CINR mean,
      - RSSI mean,
      - D-TDOA,
      - U-TDOA,
      - **GPS Orbital Data**

)
- GPS Orbital Data, which include Almanac data, Ephemeris data or other assisting data.

Enhancement (3/3): GPS Assistance Zone





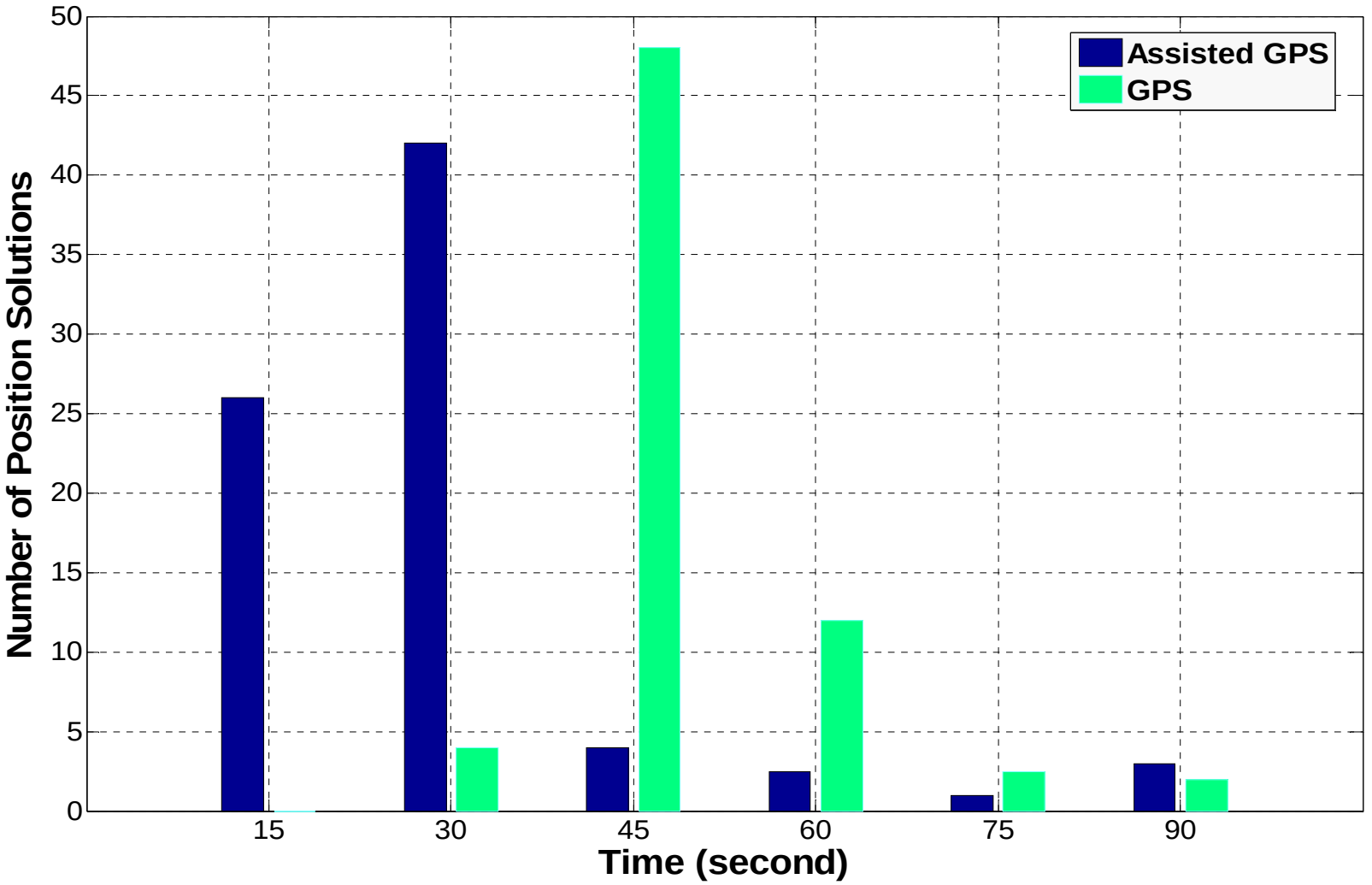
- With the assistance of GPS assistance zone and SFN broadcasting, it is easy for a GPS-capable mobile to receive the assistance from WiMAX network.
- The important assistance information for GPS positioning includes
  - Almanac: It is spread out over all 25 frames of the message.
    - For receiving the complete Almanac, the GPS receiver may need about **12.5 minutes**.
    - A detailed explanation of GPS Almanac data is in the appendix.
  - Ephemeris: It is sent in each frame by each satellite.
    - It may take the GPS receiver up to **30 seconds** to acquire Ephemeris.
- The information of Ephemeris and Almanac can be broadcast by capable base station within LBS zone.

Enhancement (3/3): GPS Assistance Zone (Con'd)

Type	Length	Value	Comment
XXX	1	0: No available LBS Zone. 1: LBS Zone in Serving BS only 2: LBS Zone in a multiple BS zone	

- This TLV indicates whether the LBS Zone service is being requested or provided for the connection that is being setup.
  - A value of 1 indicates that an MBS service limited to the serving BS is being requested
  - and a value of 2 indicates multi-BS-MBS is being requested.
- If MS or BS wants to initiate MBS service, DSA-REQ with MBS service TLV shall be used. The DSA-RSP message shall contain the acceptance or rejection of request and if there is no available LBS, LBS service value shall be set to 0.

GPS with Assistance: TTFF Gain



GPS World

Other Assistance Topics

- The GPS information can be any of
  - Precise GPS satellite orbit and clock information
    - Reference time
    - Reference location
  - Initial position and time estimate
    - Almanac
    - Acquisition assistance
    - Real-time integrity.
    - Universal Time Co-ordinates
  - Satellite selection and range information
    - Differential GPS (DGPS) corrections
    - Navigation model (contains satellite ephemeris and clock corrections)
    - Ionospheric model
    - UTC model

Proposed ToC

- **XX. Support for Location Based Services**
  - XX.1. Location Based Services Overview and Protocol Structure
  - XX.3. MAC Layer Support for Location Based Services
    - XX.3.1. Location Based Services (LBS-ADV) message
    - XX.3.2. GPS and Galileo Positioning Assistance
      - XX.3.1. GPS Zone
      - XX.3.2. GPS Almanac TLV
      - XX.3.3. GPS Ephemeris TLV
- XXX LBS Management

Proposed SDD Text

- The network shall make the GPS assistance data, including GPS Almanac data and Ephemeris data, available either through broadcast or unicast air interface messages to MS's.
- The delivery of GPS assistance data from the network to MS's can be realized by enhanced GPS broadcast or unicast messages, enhanced LBS

Reference

1) IEEE 802.16 Broadband Wireless Access Working Group IEEE 802.16m System Requirements. http://wirelessman.org/tgm/docs/80216m-07_002r4.pdf
2) P802.16Rev2/D4 (April 2008), Part 16: Air Interface for Broadband Wireless Access Systems
3) Shu Wang, Jungwon Min and Byung K. Yi, “Location Based Services for Mobiles: Technologies and Standards”, Tutorial#25, IEEE International Conference on Communication (ICC), May 23, 2008, Beijing, China.
4) Shu Wang, Jungwon Min, Li-Hsiang Sun, “Enhanced Location Based Support in cdma2000”, 3GPP2 TSG-C NTAH, Osaka, Japan, May 2008.

Appendix – GPS Almanac Data

Example: SEM Almanac Data of 4 Satellites for the Week of 09/05/2008

2	← The GPS Satellite PRN Number	
61	← The GPS Satellite “SVN” reference number	
0	← The GPS satellite "average" URA number	
8.75091552734375E-03	2.86102294921875E-05	-2.59387888945639E-09
5.15370849609375E+03	-6.53563380241394E-01	8.39705228805542E-01
-4.05330657958984E-02	1.88827514648438E-04	-3.63797880709171E-12
0	← The GPS Satellite Health	
9	← The GPS Satellite Configuration	

3		
33		
0		
1.11351013183594E-02	-5.10025024414062E-03	-2.56841303780675E-09
5.15364062500000E+03	9.82081413269043E-01	2.69389271736145E-01
-1.45777463912964E-01	2.81333923339844E-04	3.63797880709171E-12
0		
9		

4		
34		
0		
8.27789306640625E-03	-2.04086303710938E-04	-2.59387888945639E-09
5.15351708984375E+03	-6.47604107856750E-01	1.26119256019592E-01
8.53008031845093E-01	-1.67846679687500E-04	-1.09139364212751E-11
0		
9		

5		
35		
2		
9.28258895874023E-03	3.08990478515625E-04	-2.55749910138547E-09
5.15364550781250E+03	6.53590559959412E-01	4.04798626899719E-01
7.23199725151062E-01	3.52859497070312E-05	-2.11002770811319E-10
63		
9		

In reality, the data of 4 GPS satellites may be enough for a first fix. The Almanac data are stable and can be reused in weeks.
http://www.navcen.uscg.gov/GPS/almanacs.htm

1) PRN Number: The satellite PRN number per ICD-GPS-200. This is a required data item as it is the GPS user's primary means of identifying GPS satellites. It is equivalent to the space vehicle identification (SVID) number of the satellite.
2) SVN Number: The satellite "SVN" reference number. This is not a required data item and is normally included only for cross-reference with the operational control system (OCS).
3) Average URA Number: The satellite "average" URA number, with URA number as defined in ICD-GPS-200. This is not an item in the raw almanac file but is based on the average URA value transmitted by this satellite in its subframe 1 data sets.
4) Eccentricity: The satellite almanac orbital "eccentricity" (e) as defined in ICD-GPS-200.
5) Inclination Offset: The satellite almanac orbital "inclination angle offset" (8i) as defined in ICD-GPS-200. This is an item in the raw almanac file and does not include the 0.30 semicircle reference value. This should not be confused with the "lo" term in the satellite ephemeris files.
6) Rate of Right Ascension: The satellite almanac orbital "rate of right ascension" (OMFGADOT) as defined in ICD-GPS-200.
7) Square Root of Semi-Major Axis: The satellite almanac orbital "square root of the semi-major axis" (A1/2 as defined in ICD-GPS-200.
8) Longitude of Orbital Plane: The satellite almanac orbital "geographic longitude of the orbital plane at the weekly epoch" (OMEEGAO) as defined in ICD-GPS-200.
9) Argument of Perigee: The satellite almanac orbital "argument of perigee" ("small omega") as defined in ICD-GPS-200.
10) Mean Anomaly: The satellite @ac orbital "mean anomaly" (MO) as defined in ICD-GPS-200.
11) Zeroth Order Clock Correction: The satellite almanac zeroth order clock correction term (afo) as defined in ICD-GPS-200.
12) First Order Clock Correction: The satellite almanac first order clock correction term (afl) as defined in ICD-GPS-200.
13) Satellite Health: The satellite subframe 4 and 5, page 25 six-bit health code as defined in ICD-GPS-200 expressed in integer form.
14) Satellite Configuration: The satellite subframe 4, page 25 four-bit configuration code as defined in ICD-GPS-200 expressed in integer form.

Definition of A SEM Almanac

1. **GPS Week Number**: The almanac reference week (VINA) for all almanacs in this *.AL3 file per ICD-GPS-200
2. **GPS Time of Applicability**: The almanac reference time (TOA) for all almanacs in this *.AL3 file per ICD-GPS-200
3. **PRN Number**: The satellite PRN number per ICD-GPS-200. This is a required data item as it is the GPS user's primary means of identifying GPS satellites. It is equivalent to the space vehicle identification (SVID) number of the satellite.
4. **SVN Number**: The satellite "SVN" reference number. This is not a required data item and is normally included only for cross-reference with the operational control system (OCS).
5. **Average URA Number**: The satellite "average" URA number, with URA number as defined in ICD-GPS-200. This is not an item in the raw almanac file but is based on the average URA value transmitted by this satellite in its subframe 1 data sets.
6. **Eccentricity**: The satellite almanac orbital "eccentricity" (e) as defined in ICD-GPS-200.
7. **Inclination Offset**: The satellite almanac orbital "inclination angle offset" (8i) as defined in ICD-GPS-200. This is an item in the raw almanac file and does not include the 0.30 semicircle reference value. This should not be confused with the "lo" term in the satellite ephemeris files.
8. **Rate of Right Ascension**: The satellite almanac orbital "rate of right ascension" (OMFGADOT) as defined in ICD-GPS-200.
9. **Square Root of Semi-Major Axis**: The satellite almanac orbital "square root of the semi-major axis" (A1/2 as defined in ICD-GPS-200.
10. **Longitude of Orbital Plane**: The satellite almanac orbital "geographic longitude of the orbital plane at the weekly epoch" (OMEEGAO) as defined in ICD-GPS-200.
11. **Argument of Perigee**: The satellite almanac orbital "argument of perigee" ("small omega") as defined in ICD-GPS-200.
12. **Mean Anomaly**: The satellite @ac orbital "mean anomaly" (MO) as defined in ICD-GPS-200.
    Zeroth Order Clock Correction: The satellite almanac zeroth order clock correction term (afo) as defined in ICD-GPS-200.
13. **First Order Clock Correction**: The satellite almanac first order clock correction term (afl) as defined in ICD-GPS-200.
14. **Satellite Health**: The satellite subframe 4 and 5, page 25 six-bit health code as defined in ICD-GPS-200 expressed in integer form.
15. **Satellite Configuration**: The satellite subframe 4, page 25 four-bit configuration code as defined in ICD-GPS-200 expressed in integer form.

Source: http://www.navcen.uscg.gov/GPS/almanacs.htm

Q&A (1/2)

- Is the proposed N-GPS concept new for WiMAX?
  - It is not new for WiMAX. Actually in 16e, there are two GPS assistances available.
    - The GPS Time TLV
    - The GPS Frequency TLV
  - However, from a A-GPS receiver design perspective, these two assistances are far from enough. The introduction of GPS Almanac is very important for GPS based positioning.
- Do we need any changes in MAC/PHY for LBS?
  - We need something above L2 for LBS for sure.
  - However, I do see the necessity of MAC/PHY changes because the current design including 16e was optimized for data with no enough consideration on LBS and there are many LBS issues to be solved. For example,
    1) indoor positioning and Femto cell synchronization.
    2) hearability issues.
    3) It is necessary for the accuracy and latency to be improved, maybe only for satisfying E911 mandates.

Q&A (2/2)

- What do you mean “the A-GPS Roaming Issue”?
  - In reality, the A-GPS assistance is usually controlled by the services providers.
  - If you are a US A-GPS customer and someday you are roaming in the network of a Canada operator, you may not be able to access the A-GPS service provided by your US service provider. This can be true
    - not only because there may not be A-GPS roaming agreement between these two
    - but also because the US operator’s assistance server has not assistance information for an area it has no coverage.
  - In addition, you may not able to use the A-GPS services provided by the Canada operator without an additional subscription to their services, even though the Canada A-GPS server has the capability to serve your phone.

- What do you mean the access control for A-GPS services?
  - If you have a 3rd party AGPS assistance for your mobile, then there are two possible scenarios, for example.
    - Scenario One: You want you A-GPS assistance and location related information to be under privacy control. I guess you don’t want your boss to know where you are without your permission.
    - Scenario Two: If the service is not free, the 3rd party wants to make sure you are the people authorized for the services.
  - In either case, if you really like the A-GPS assistance, you need something like OMA PCP.

OMA LCS: User Plane

- **Open Mobile Alliance**
  - OMA LOC (Location Working Group) develops specifications to ensure interoperability of location services (LCS).
  - LIF (Location Interoperation Forum) has consolidated into OMA. OMA LOC continues the work originated in the former LIF.
- **MLS (Mobile Location Service)**
  - MLS is a set of three protocols.
    - MLP: Mobile Location Protocol
    - RLP: Roaming Location Protocol
    - PCP: Privacy Checking Protocol
- **SUPL (Secure User Plane Location)**
  - SUPL utilizes existing standard to transfer assistance data and positioning data over a user plane bearer.
  - SUPL is an alternative and complementary solution to existing 3GPP and 3GPP2 control plane architecture.
  - SUPL supports all handset based and assisted positioning technologies.
  - SUPL is data bearer independent.