Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Location Based Services**
Date Submitted	**2006-07-20**
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Re:	
Abstract	This contribution proposes mechanisms in supporting location based services.
Purpose	Adoption
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1. Introduction

Location Based Services (LBS) is a new breed of wireless services that promises service differentiation and increasing revenue for mobile network operators. LBS typically includes location based information, location based billing, and emergency services that has been a FCC's mandate for supporting Emergency 911 services. All these LBS requires the provision of mobile station location to network providers.

2. Location Based Services

This contribution proposes text to be adopted in 802.16g in order to support location based services..

3. Definitions

[Insert a new definition:]

3.89 Location Based Services (LBS): Services that are provided through the use of MS location data. Examples of LBS include includes location based information, location based billing, navigation, emergency services, and equipment tracking in the field.

6. MAC Common Part Sublayer

[Insert a new subclause:]

6.3.26 Location Based Services

This subclause provides mechansisms to coordinate the collection, generation, and reporting of location information (e.g. RSSI, CINR, Time Difference of Arrival (TDOA), Time of Arrival (TOA), …) that may be used to calculate MS locations.

6.3.26.1 Time Difference of Arrival

TDOA scheme measures the difference of time arrival for packet transmission between a MS and multiple BSs. There are two types of TDOA – Downlink TDOA (D-TDOA) and Uplink TDOA (U-TDOA) that are measured in MS and BS, respectively.

- D-TDOA – MS may report D-TDOA data in the Relative Delay parameter in MOB_SCN-REP meesage that indicates the delay of DL signals from neighbor BS relative to the serving BS. MOB_SCN-REP also reports RSSI and CINR of SL signals from neighbor BS that can be used for MS location estimation. During SBC-REQ/RSP negotiation, HO Trigger metric support (see 11.8.7) indicates which trigger metric that MS support.

- U-TDOA – As oppose to D-TDOA that is reported each time MS scanning is completed, T-TDOA enables BS to initiate T-TDOA measurement when it is needed. Basically, serving BS initiates T-TDOA measurement by sending autonomous MOB_SCN-RSP with scanning type = 0b10 (scan association with coordination) to force MS

performing initial ranging after scan. Annex I shows how U-TDOA data can be measured through the coordination between MS, serving BS, and non-serving BSs.

6.3.2.3.47 Neighbor Advertisement (MOB_NBR-ADV) message

[Insert BS Geo Location TLV to Table 109f:]

Table 109f—MOB_NBR-ADV message format

Syntax	Size	Note
For (j=0 ; j<N_NEIGHBORS ; j++) {	—	---
Length	8 bits	Length of message information within the iteration of N_NEIGHBOR in bytes.
PHY Profile ID	8 bits	Aggregated IDs of Co-located FA Indicator, FA Configuration Indicator, FFT size, Bandwidth, Operation Mode of the starting subchannelization of a frame, and Channel Number.
BS Geo Location TLV	15 bytes	BS geo location to be used for MS location estimation.
:		
}		

[Insert the following subclause:]

BS Geo Location TLV (see 11.23)

It contains BS geo location in Latitude, Longitude, and altitude that will be used for MS location estimation.

11.23 MS / BS Geo Location

The fields indicate the MS / BS location in latitude, longitude, and altitude that are based on the LCI (Location Configuration Information) format as defined in RFC3825. Latitude and longitude are represented in 34 bits fixed-point 2s-complement number, consisting of 9 bits of integer and 25 bits of fraction. Altitude is represented in 30 bits fixed-point 2s-complement number with 22 bits of integer and 8 bits of fraction. Latitude and longitude shold be normalized to within +/- 90 degrees and +/- 180 degrees, respectively. Each field also includes resolution bits that define the number of valid bits in the fixed-point value. Here are the definition of 2s-complement number.

- Positive numbers
  - Latitide – North
  - Longitude – East
  - Altitude – above ground
- Negtive numbers
  - Latitide – South
  - Longitude – West
  - Altitude – below ground

The structure of these fields shall be little-endian.

Name	Type	Length	Value	Scope
Longitude	1	5	Bits # 0-5: longitude resolution 1-34 – number of valid bits in fixed-point value of longitude value 35 – MS geo location not supported Others – reserved Bits # 6-14: longitude integer Bits # 15-39: longitude fraction	MOB_NBR-ADV
Latitude	2	5	Bits # 0-5: latiitude resolution 1-34 – number of valid bits in fixed-point value of latitude value 35– MS geo location not supported Others – reserved Bits # 6-14: latitude integer Bits # 15-39: latitude fraction	MOB_NBR-ADV
Altitude	3	5	Bits # 0-3: altitude type 1 – meters 2 – floors Others – reserved Bits # 4-9: altitude resolution 1-30 – number of valid bits in fixed-point value of altitude value 31 – MS geo location not supported Others – reserved Bits # 10-31: altitude integer Bits # 32-39: altitude fraction	MOB_NBR-ADV

[Insert annex I:]

Annex I U-TDOA measurement

Figure I.1 shows a network diagram for U-TDOA measurement.

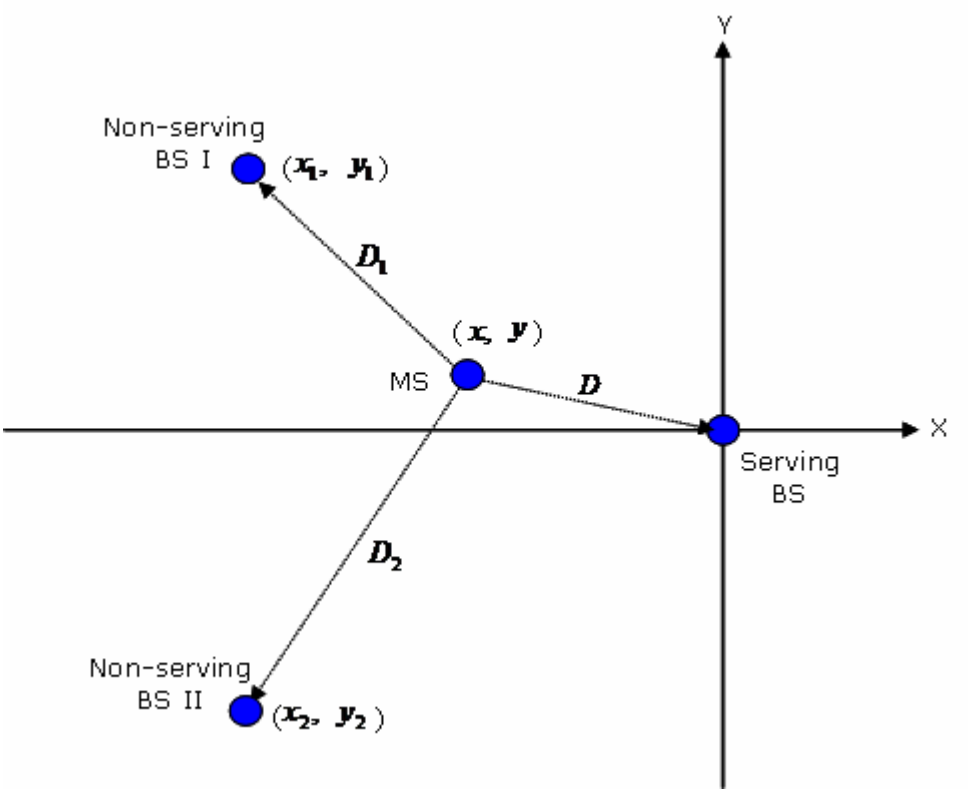

Figure I.1: Network Diagram for U-TDOA Measurement

Figure I.2 shows the timing diagram of U-TDOA measurement. t_1 is the Timing Advance. t_2 and t_3 are the intervals between the time of burst arrival and the beginning of granted slot for Serving BS and Non-serving BS 1 respectively. t_2 and t_3 are also the Timing Adjustments that BS will ask MS to adjust the timing advance when transmitting the next UL burst. BS calculates t_2 and t_3 during the ranging process.

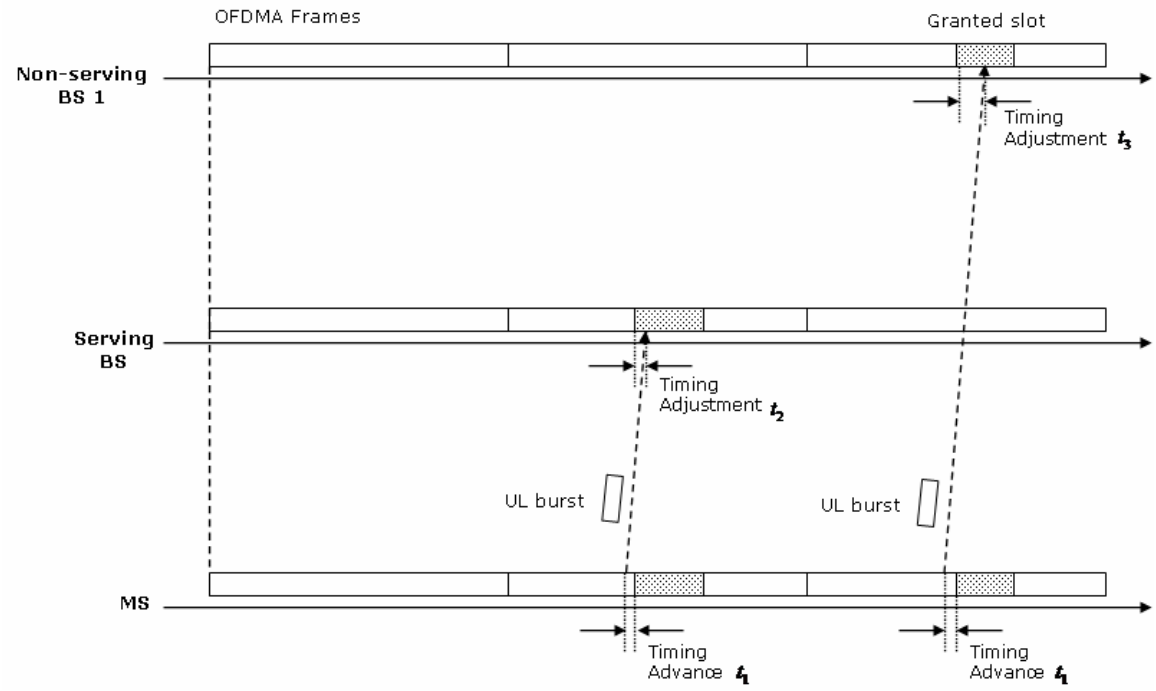

Figure I.2: U-TDOA Measurement Timing Diagram

The propagation delay for serving BS and non-serving BS 1 can be derived from the equation below, assuming the frames of serving BS and non serving BS are synchronized. The U-TDOA can be measured even before the MS is successfully ranged. The propagation delay for non-serving BS II can be obtained from the same approach.

Propagation delay MS → serving BS $$\frac{D}{C} = t_1 + t_2 \quad (1)$$

Propagation delay MS → non-serving BS $$\frac{D_1}{C} = t_1 + t_3 \quad (2)$$

Therefore, TDOA T_1 can be shown as follows:

$$T_1 = (t_1 + t_2) - (t_1 + t_3) \quad (3)$$

Figure I.3 shows the U-TDOA measurement algorithm that includes a non-serving BS. The algorithm can be duplicated to support additional non-serving BS. Here are the assumptions for the algorithm.

- The neighboring sectors of serving BS and non-serving BS are operating on the different band.
- Serving BS and non-serving BS are operating on the same frame duration
- The frames in both serving BS and non-serving BS are synchronized
- MS can communicates with both serving BS and non-serving BS

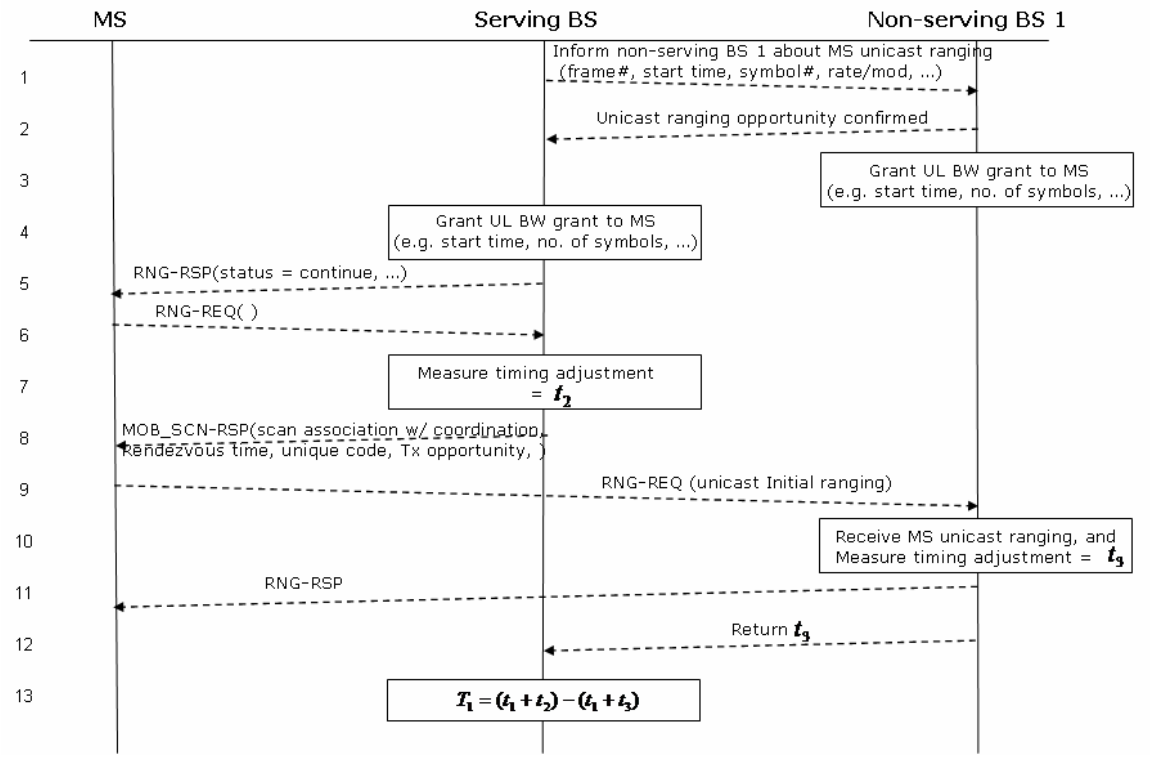

Figure I.3: U-TDOA Measurement Algorithm

1. Serving BS informs non-serving BS 1 about MS is going to do unicast ranging by passing frame number, start time, number of symbols, …
2. Non-servicing BS 1 confirms unicast ranging opportunity for MS
3. Non-serving BS 1 grant such UL slot to the MS
4. Serving BS allocates a UL slot for MS to do unicast ranging.
5. Serving BS sends an autonomous RNG-RSP message to ask MS performing unicast ranging
6. When MS receives the RNG-RSP from serving BS, it shall send RNG-REQ at the assigned slot
7. Serving BS 1 measures Timing Adjustment t_2
8. Serving BS sends autonomous MOB_SCN-RSP with scanning type = 0b10 (scan association with coordination) to force MS performing initial ranging after scan
9. MS synchronizes with non-serving BS 1, and sends RNG-REQ
10. Non-serving BS 1 receives unicast ranging, and measures Timing Adjustment t_3
11. Non-serving BS returns RNG-RSP to MS
12. Non-serving BS returns t_3 to serving BS

13. Serving BS reads the Timing Advance t_1 that was captured previously, and calculates U-TDOA $T_1 = (t_1 + t_2) - (t_1 + t_3)$