Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Location Measurement Enhancements for meeting E911 Phase II Accuracy Requirements**
Date Submitted	**2006-11-10**
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Abstract	This contribution proposes location measurement enhancements that are necessary to meet E911 Phase II requirements, and the needs for other Location Based Services (LBS).
Purpose	Adoption
Notice	
Release	
Patent Policy and Procedures	

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1. Introduction

This contribution proposes location measurement enhancements that are necessary to meet E911 Phase II requirements, and the needs for other Location Based Services (LBS).

2. Proposed Changes

The wireless Enhanced 911 (E911) [1] rules seek to improve the effectiveness and reliability of wireless 911 service by providing 911 dispatchers with additional information on wireless 911 calls. The wireless E911 program is divided into two parts - Phase I and Phase II. Phase I requires carriers, upon valid request by a local Public Safety Answering Point (PSAP), to report the telephone number of a wireless 911 caller and the location of the BS that received the call. Phase II requires wireless carriers to provide far more precise location information.

The FCC has set the following accuracy and reliability requirements for E911 Phase II operations:

> “For network-based solutions: 100 meters for 67 percent of calls, 300 meters for 95 percent of calls; For handset-based solutions: 50 meters for 67 percent of calls, 150 meters for 95 percent of calls. [2]”

Several factors can contribute to errors in the MS location estimate. Specifically, time-based ranging methods such as, TDOA (Time-Difference of Arrival) or TOA (Time of Arrival) measurements can be affected by multi-path fading, MS and BS synchronization, and the quantization error. Multi-path fading errors can be mitigated by advanced signal processing or directional antennas. Directional antenna technologies, such as setor antennas, MIMO (Multiple-Input Multiple-output), and beam forming can be used to help mitigate this phenomenona.

The U-TDOA measurement algorithm uses the Timing Adjustment parameter as derived from ranging procedure to calculate the TDOA. The unit of the Timing Adjustment is 1/Fs for OFDM and OFDMA PHY. Therefore, for a typical 3.5MHz channel with 4MHz sampling clock, the resolution of the Timing Adjustment is 250ns that translates to 75 meters. As the result, E911 Phase II requirement will not be met, since this resolution does not have enough margin to accommodate other factors, as mentioned previously.

This contribution proposes using the unit of “nano seconds” for all TDOA measurement reporting. The unit of the Timing Adjustment in RNG-RSP and the Relative Delay in MOB_SCN-REP can remain the same as currently defined in the standard. As the technologies advance, both BS and MS will improve the accuracy of relative delay and timing advance measurement respectively, so the additional bits in the TDOA parameters can be utilized in order to meet E911 Phase II requirements.

2.1 D-TDOA Parameter Changes

D-TDOA parameter is provided in Relative Delay parameter in MOB_SCN-REP message that indicates the delay of DL signals from a neighbor BS relative to the serving BS. The unit of the Relative Delay is samples. Since the sample duration is tied to the channel bandwidth, the resolution of D-TDOA parameter can not be guranteed. This contribution proposes changing the unit of Relative Delay to “nano seconds”.

6.3.2.3.50 Scanning Result Report (MOB_SCN-REP) message

[Change the size of Relative Delay parameter in Table 109j to 16 bits:]

Table 109j—MOB_SCN-REP message format

Syntax	Size	Note
For (j=0; j<N_current_BSs; j++) {		
:		
If (Report metric[Bit 2]==1)	—	---
Relative Delay	16 bits	In case FBSS/MDHO is in progress, this field shall include the relative delay of BSs currently in the diversity set, except for that of the Anchor BS. iteration of N_NEIGHBOR in bytes.
:		
}		
For (j=0; j<N_Neighbor_BS_Index; j++) {		
:		
If (Report metric[Bit 2]==1)	—	---
Relative Delay	16 bits	---
}		
For (j=0; j<N_Neighbor_BS_Full; j++) {		
:		
If (Report metric[Bit 2]==1)	—	
Relative Delay	16 bits	
}		

[Change the description of Relative Delay parameter:]

Relative delay

This parameter indicates the delay of neighbor DL signals relative to the serving BS, as measured by the MS for the particular BS. The value shall be interpreted as a signed integer in units of nano seconds.

6.3.2.3.53 MS HO Request (MOB_MSHO-REQ) message

[Change the size of Relative Delay parameter in Table 109m to 16 bits:]

Table 109m—MOB_SCN-REQ message format

Syntax	Size	Note
For (j=0; j<N_New_BS_Index; j++) {		
:		
If (Report metric[Bit 2]==1)	—	---
Relative Delay	16 bits	

:		
}		
For (j=0; j< N_New_BS_Full; j++) {		
:		
If (Report metric[Bit 2]==1)	—	---
Relative Delay	16 bits	---
:		
}		
For (j=0; j<N_Current_BSs; j++) {		
:		
If (Report metric[Bit 2]==1)	—	
Relative Delay	16 bits	Only when FBSS/MDHO is in progress, this field will include the relative delay of BSs currently in the diversity set, except anchor BS.
:		
}		

[Change the description of Relative Delay parameter to the following:]

Relative delay

This parameter indicates the delay of neighbor DL signals relative to the serving BS, as measured by the MS for the particular BS. The value shall be interpreted as a signed integer in units of nano seconds.

14.2.13.3.1 LBS Parameters

[Change the description of D-TDOA to the following:]

• D-TDOA - indicates the delay of DL signals that MS received from a neighboring BS, as identified by BS ID, relative to the serving BS. The value shall be interpreted as a signed integer in units of nano second.

2.2 U-TDOA Parameter Changes

14.2.13.3.1 LBS Parameters

[Change the description of U-TDOA to the following:]

• U-TDOA - indicates the delay of UL signals that a neighboring BS, as identified by BS ID, receives from the MS, relative to the serving BS. The value shall be interpreted as a signed integer in units of nano second.

2.3 U-TDOA Measurement Changes

Annex G U-TDOA measurement

[Insert the following text after Figure G1:]

The U-TDOA measurement algorithm is based on the ranging mechanism as defined in IEEE 802.16 standard. It should be noted that the ranging capability was designed for MS to synchronized with BS in terms of time and frequency, and may not provide sufficient accuracy for LBS applications, such as E911 Phase II. It is recommended that the Automatic Timing Correction (ATC) algorithm in the BS should use better resolution (e.g. in the increments of 50ns or 25ns) than what is required for the timing adjustment increments of the ranging procedure.

G.1 FRF > 1

Figure G2 does not take into account the one way propagation delay from BS to MS.

[Change Figure G2 and Figure title with the following diagram:]

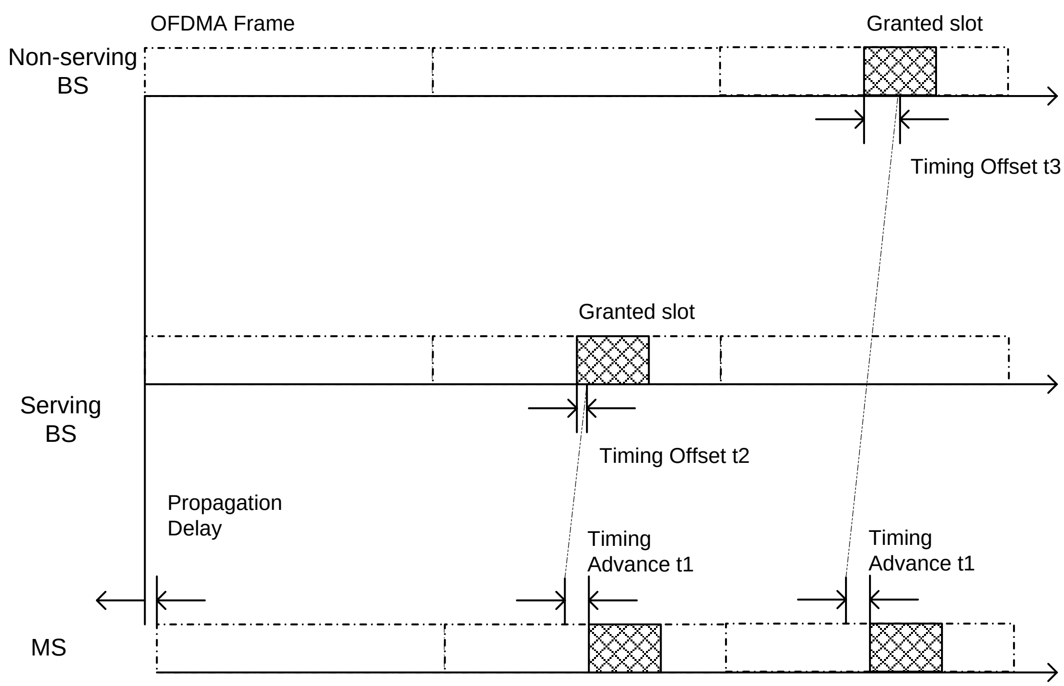

Figure G2—U-TDOA Measurement Timing Diagram (FRF > 1)

[Change the paragraphs after Figure G2 as the following:]

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 sum of timing adjustment and timing advance equals to two times of MS to BS propagation delay. The propagation delay for non-serving BS II can be obtained from the same approach.

Propagation delay MS → serving BS $\frac{D}{C} = (t_1 + t_2)/2$ (1)

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

Therefore, TDOA T_1 can be shown as follows:

$$T_1 = (t_1 + t_2)/2 - (t_1 + t_3)/2 \qquad (3)$$

[Change Figure G3 and Figure title with the following diagram:]

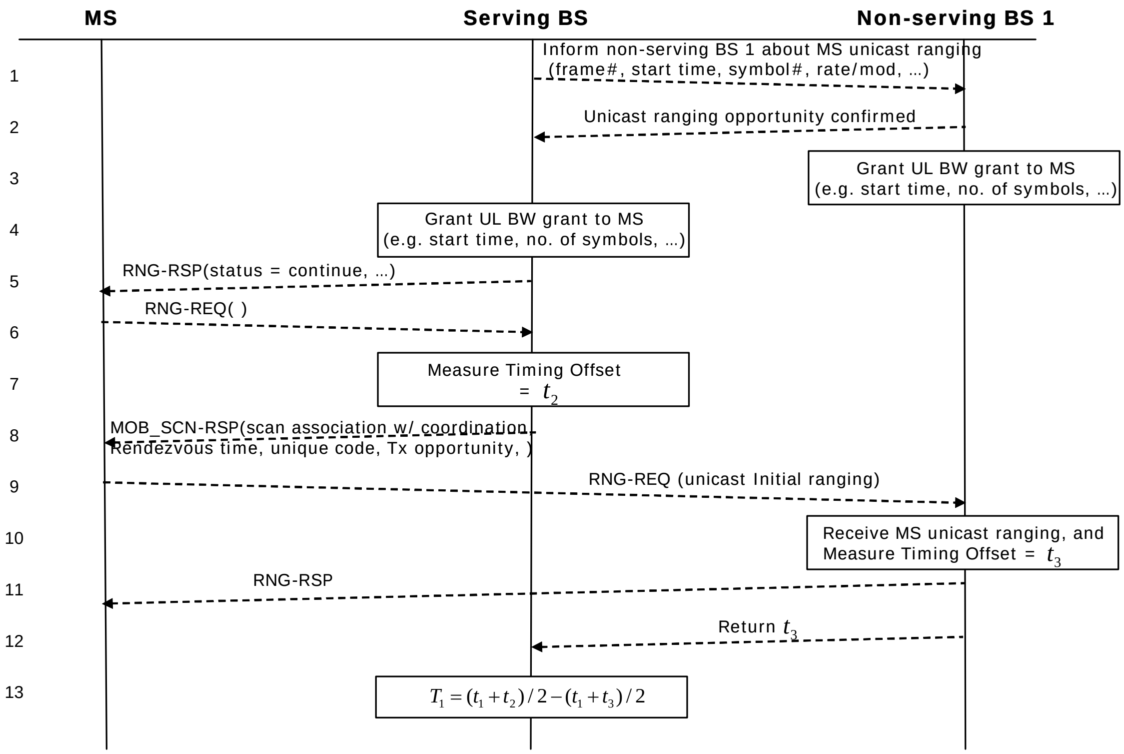

Figure G3—U-TDOA Measurement Algorithm (FRF > 1)

[Change the algorithm as the following:]

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 (Ranging Status = Continue) 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 Offset 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 with Timing Adjustment = $t_1 + t_2$ to MS
12. Non-serving BS returns Timing Offset t_3 to serving BS
13. Serving BS reads the Timing Advance t_1 that was captured previously, and calculates U-TDOA $T_1 = (t_1 + t_2)/2 - (t_1 + t_3)/2$

G.2 FRF = 1

Figure G4 does not take into account the one way propagation delay from BS to MS.

[Change Figure G4 and Figure title with the following diagram:]

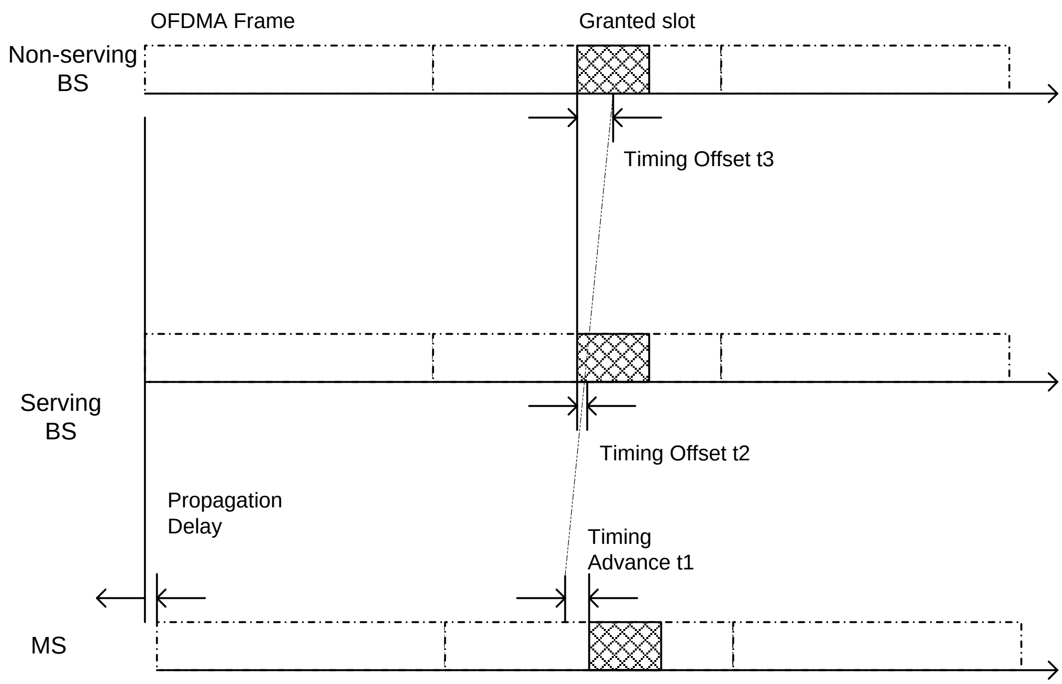

Figure G4—U-TDOA Measurement Timing Diagram (FRF = 1)

[Change the paragraphs after Figure G4 as the following:]

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 sum of timing adjustment and timing advance equals to two times of MS to BS propagation delay. The propagation delay for non-serving BS II can be obtained from the same approach.

Propagation delay MS → serving BS $$\frac{D}{C} = (t_1 + t_2)/2 \quad (6)$$

Propagation delay MS → non-serving BS $$\frac{D_1}{C} = (t_1 + t_3)/2 \quad (7)$$

Therefore, TDOA T_1 can be shown as follows:

$$T_1 = (t_1 + t_2)/2 - (t_1 + t_3)/2 \quad (8)$$

[Change Figure G5 and Figure title with the following diagram:]

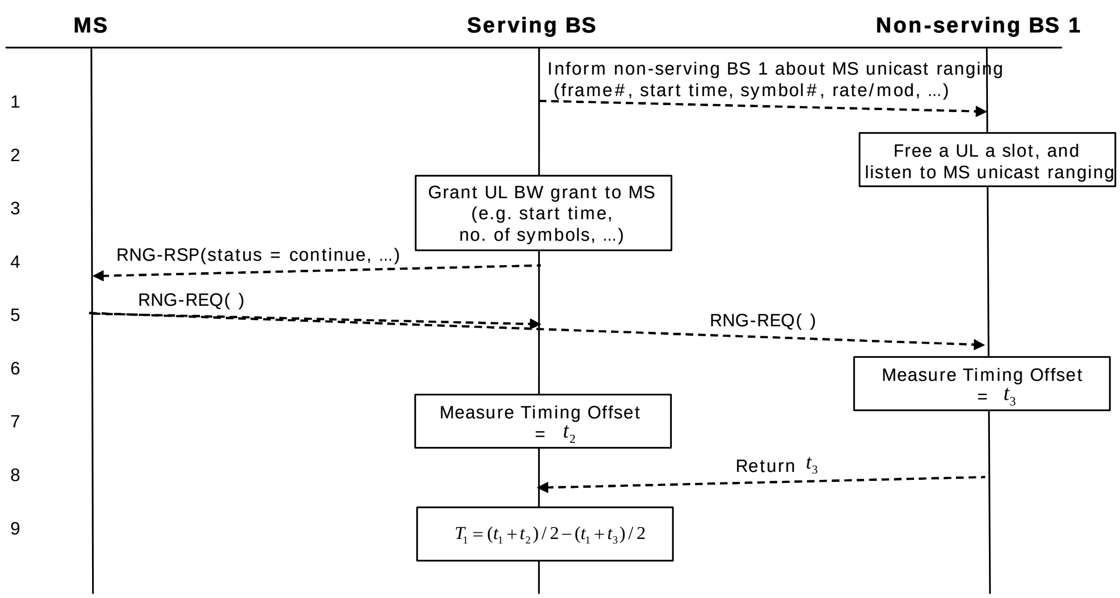

Figure G5—U-TDOA Measurement Algorithm (FRF = 1)

[Change the algorithm as the following:]

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-serving BS 1 does not grant such UL slot to any MS, and listens to the unicast ranging from MS
3. Serving BS allocates a UL slot for MS to do unicast ranging.
4. Serving BS sends an autonomous RNG-RSP message (Ranging Status = Continue) to ask MS performing unicast ranging
5. When MS receives the RNG-RSP from serving BS, it shall send RNG-REQ at the assigned slot that can be received by non-serving BS.
6. Non-serving BS 1 measures Timing Offset t_3
7. Serving BS measures Timing Offset t_2
8. Non-serving BS 1 returns Timing Offset t_3 to serving BS
9. Serving BS reads the Timing Advance t_1 that was captured previously, and calculates U-TDOA $T_1 = (t_1 + t_2)/2 - (t_1 + t_3)/2$

3. References

[1] FCC, “Enhanced 911 Wireless Service,” http://www.fcc.gov/911/enhanced/, February, 2005.

[2] FCC, “Guidelines for Testing and Verifying the Accuracy of Wireless E911 Location Systems,” *OET Bulletin No. 71*, pp. 4-12, April 12, 2000.