Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Location Based Services**
Date Submitted	**2006-09-22**
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Re:	
Abstract	This contribution proposes mechanisms in supporting location based services.
Purpose	Adoption
Notice	
Release	
Patent Policy and Procedures	

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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

6.3.2.3 MAC management messages

[*Add the following entry to Table 14a, after deleting the last row as shown*]

Table 14a— MAC management messages

Type	Message Name	Message Description	Connection
75	LBS-ADV	LBS information broadcast	Broadcast
76-255		*Reserved*	

[Insert the following subclausess:]

6.3.2.3.65 Location Based Services (LBS-ADV) message

A BS may use the LBS-ADV message to broadcast the LBS information. The message may be broadcast periodically without solicitation or could be solicited by an (M)SS. This message is sent from the BS to all MSs on a broadcast CID.

Syntax	Size	Note
LBS-ADV_Message_Format( ) {	LBS-ADV	
Management Message Type = 75		
Number_of_BS	8 bits	Total number of serving BS and neighbor BSs
For (j = 0 ; j < Number_of_BS ; j++) {		
Length	8 bits	Length of message information within the iteration of Number_of_BS in bytes.
BSID	24 bits	The least significant 24 bits of the Base Station ID parameter in the DL-MAP message of the Serving BS or Neighbor BS.
TLV encoded information	*Vatiable*	TLV specific
}		
}		

The LBS-ADV shall include the following TLV.

BS Coordicate Broadcast (see 11.22)
BS uses this TLV to broadcast BS's coordicate.

[Insert the following subclausess:]

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, U-TDOA enables BS to initiate U-TDOA measurement when it is needed. Annex I shows how U-TDOA data can be measured through the coordination of MS, serving BS, and non-serving BSs.

[Insert a new subclause:]

11.22 BS Coordinate Broadcast

This compound TLV is used for BS coordinate broadcast.

Type	Length	Value	Scope
45	*Variable*	Compound	LBS-ADV

The 'Location Measurement Method' indicates the method used to measure the device location. If the device support multiple methods, it can choose any method for measuring the 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	45.1	5	Bits # 0-5: longitude resolution 1-34 – number of valid bits in fixed-point value of longitude value 35 – LBS not supported Others – reserved Bits # 6-14: longitude integer Bits # 15-39: longitude fraction	LBS-ADV
Latitude	45.2	5	Bits # 0-5: latiitude resolution 1-34 – number of valid bits in fixed-point value of latitude value 35– LBS not supported Others – reserved Bits # 6-14: latitude integer Bits # 15-39: latitude fraction	LBS-ADV
Altitude	45.3	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 – LBS not supported Others – reserved Bits # 10-31: altitude integer Bits # 32-39: altitude fraction	LBS-ADV

[Insert a new subclause:]

14.2.12 LBS Management

LBS Management provides a set of primitives for NCMS to retrieve parameters that are required for supporting LBS. Figure 515 depicts the LBS Management primitives.

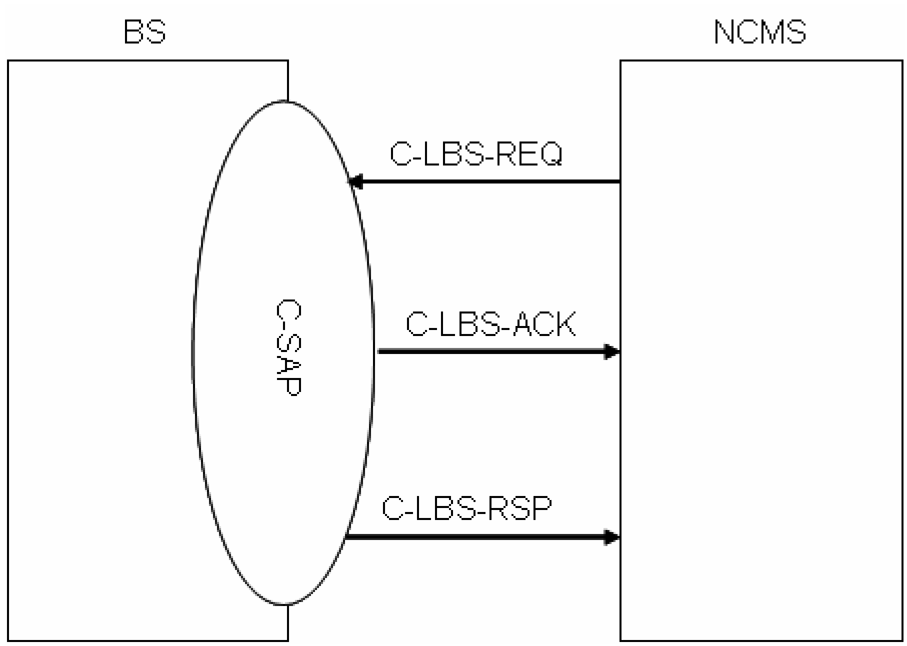

Figure 515: LBS Management Primitives

Operation Type	Description
Get	LBS parameters

14.2.12.1 C-LBS-REQ

NCMS sends C-LBS-REQ primitive

14.2.12.1.1 LBS Parameters

Function:

This primitive is used by NCMS to request LBS parameters that are needed for estimating the MS location.

Semantics of the service primitive:

The parameters of the primitive are as follow:

C-LBS-REQ
(
Operation_type: Get,
Action_type: Null,
Object_ID: BS
Attribute_List:
MS MAC Address,
Sequence Number,
LBS Parameter Types
)

MS MAC Address
48-bit MAC address that identifies the MS.

Sequence Number
This number is used to associate the ACK / RSP with REQ. This number is incremented each time C-LBS-REQ is sent, and wraps around when it reaches the limit .

LBS Parameter Types
Identify the types of LBS parameter requested by NCMS. It is a bit field {CINR, RSSI, D-TDOA, U-TDOA}. "1" in each bit indicates the corresponding parameter is requested.

When generated

A trigger from a LBS application (e.g E911 service) will initiate NCMS to call this primitive.

Effect of receipt

When this primitive is called, the BS will send C-LBS-ACK to NCMS to acknowledge the receiption of C-LBS-REQ, and then execute the necessary procedure to collect the LBS of parameters.

14.2.12.2 C-LBS-ACK

14.2.12.2.1 LBS Parameters

Function:

This primitive acknowledges that C-LBS-REQ has been received.

Semantics of the service primitive:

The parameters of the primitive are as follow:

C-LBS-ACK
(
Operation_type: Get,
Action_type: Null,
Object_ID: NCMS
Attribute_List:
MS MAC Address,
Sequence Number
)

MS MAC Address

48-bit MAC address that identifies the MS.

Sequence Number

This number is used to associate the ACK / RSP with REQ. This number is incremented each time C-LBS-REQ is sent, and wraps around when it reaches the limit .

When generated

The receiption of C-LBS-REQ.

Effect of receipt

Null

14.2.12.3 C-LBS-RSP

14.2.12.3.1 LBS Parameters

Function:

This primitive is used by BS to return LBS parameters as requested in C-LBS-REQ.

Semantics of the service primitive:

The parameters of the primitive are as follow:

```
C-LBS-RSP
    (
    Operation_type: Get,
    Action_type: Null,
    Object_ID: NCMS
    Attribute_List:
            MS MAC Address,
            Sequence Number,
            Requested LBS Parameters [ ]
                    BS ID,
                    CINR mean,
                    RSSI mean,
                    D-TDOA,
                    U-TDOA
    )
```

MS MAC Address

48-bit MAC address that identifies the MS.

Sequence Number

This number is used to associate the ACK / RSP with REQ. This number is incremented each time C-LBS-REQ is sent, and wraps around when it reaches the limit .

Requested LBS Parameters [ ]

Requested LBS Parameters is an array that contains the following parameters:

- BS ID – BS unique identifier of serving BS and neighboring BSs, and is used as the index of the array.
- CINR mean – indicates the mean CINR measured by the MS from the serving BS or neighboring BSs as identified in BS ID. The value shall be interpreted as a signed byte with units of 0.5 dB.
- RSSI mean – indicates the mean RSSI measured by the MS from the serving BS or neighboring BSs as identified in BS ID. The value shall be interpreted as an unsigned byte with units of 0.25 dB, such that 0x00 is interpreted as –103.75 dBm, an MS shall be able to report values in the range –103.75 dBm to –40 dBm.
- 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 micro second.
- 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 micro second.

When generated

The receiption of C-LBS-REQ.

Effect of receipt

This primitive returns the LBS parameters to NCMS.

[Insert annex I:]

Annex I U-TDOA measurement

Annex I describes the U-TDOA measurement for networks based on FRF (Frequency Reuse Factor) > 1 (e.g. 1X3X3), and FRF = 1 (e.g. 1X3X1 or 1X1X1). Figure I.1 shows a diagram for U-TDOA measurement.

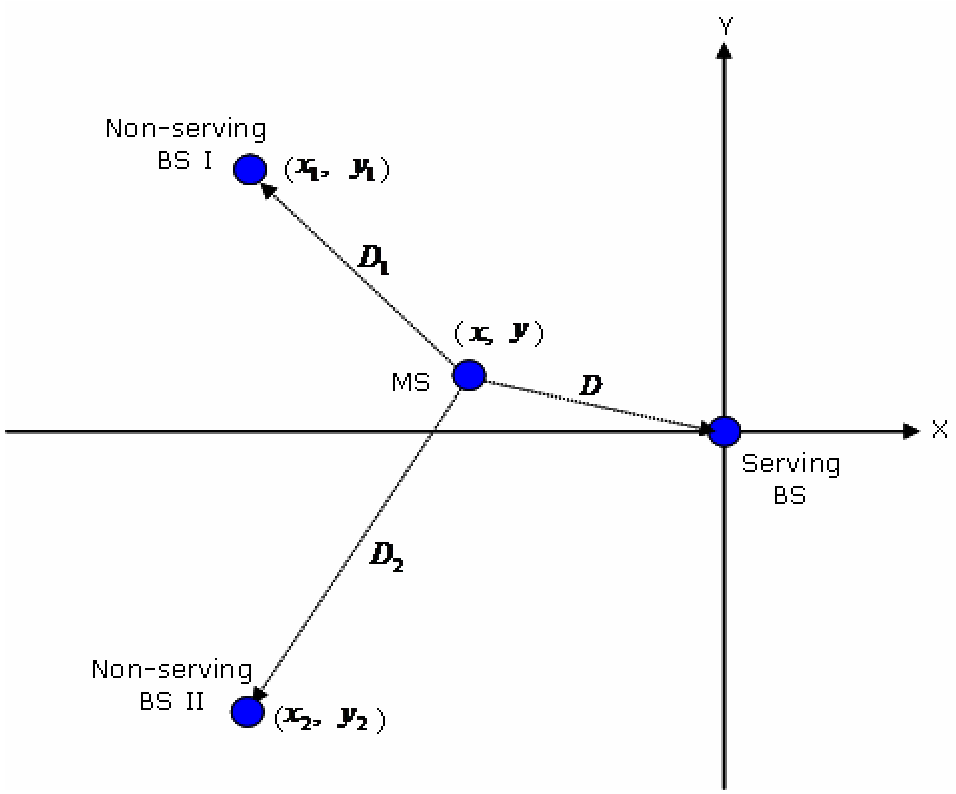

Figure I.1: Network Diagram for U-TDOA Measurement

I.1 FRF > 1

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.

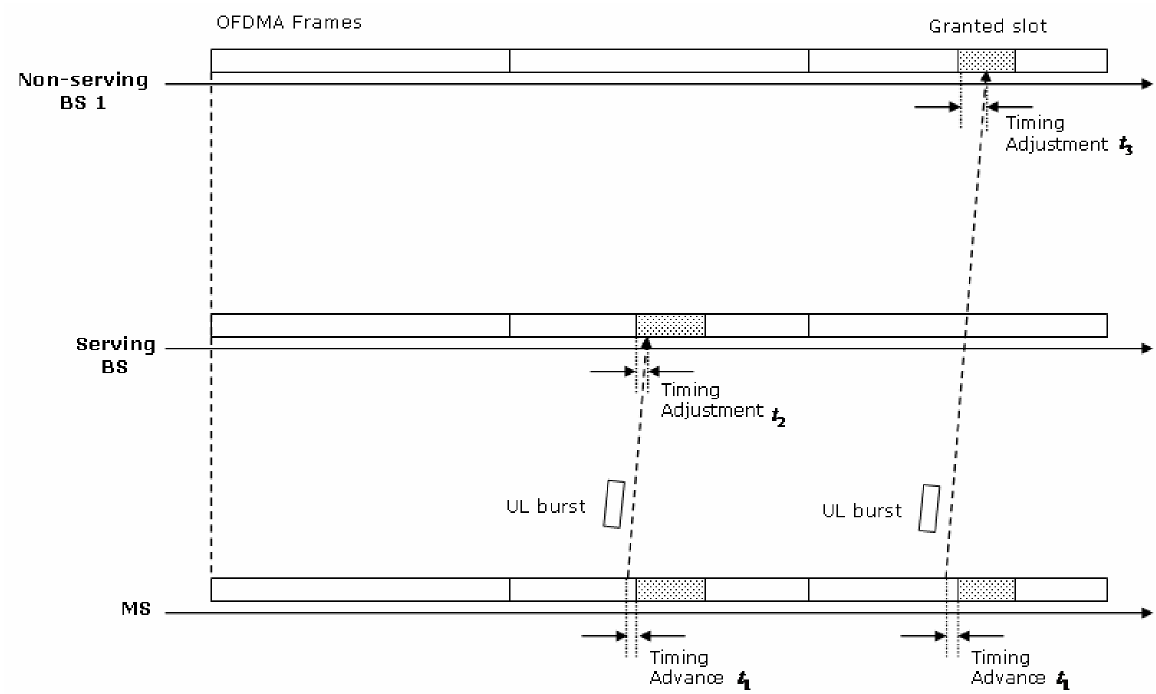

Figure I.2: U-TDOA Measurement Timing Diagram

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

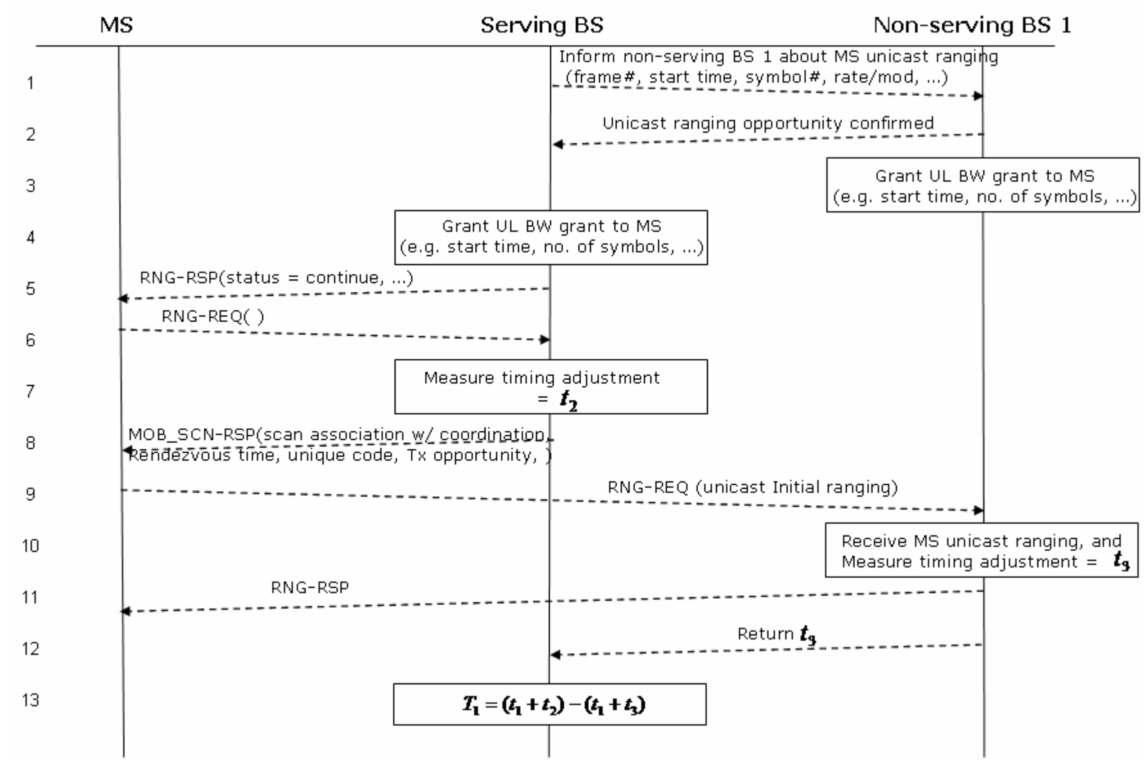

Figure I.3: U-TDOA Measurement Algorithm

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 $T_1 = (t_1 + t_2) - (t_1 + t_3)$

I.2 FRF = 1

Figure I.4 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.

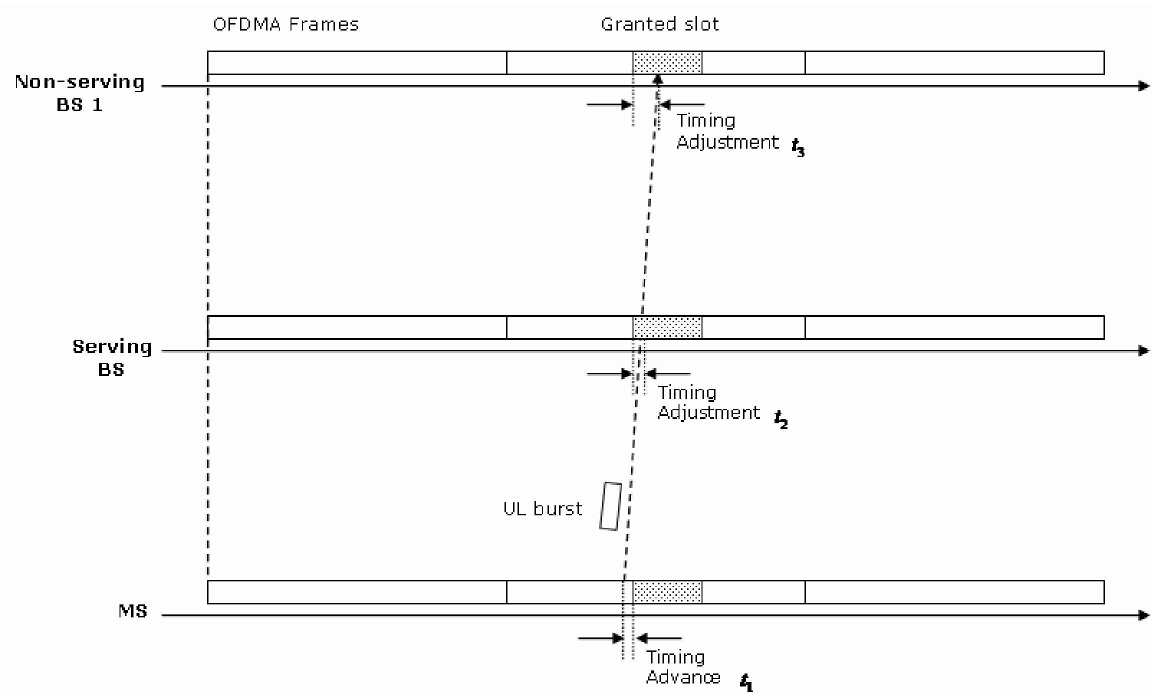

Figure I.4: U-TDOA Measurement Timing Diagram

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 $$\frac{D}{C} = t_1 + t_2 \quad (6)$$

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

Therefore, TDOA T_1 can be shown as follows:

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

Figure I.5 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.

- Serving BS and non-serving BS are operating on the same band (Frequency reuse = 1)
- 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

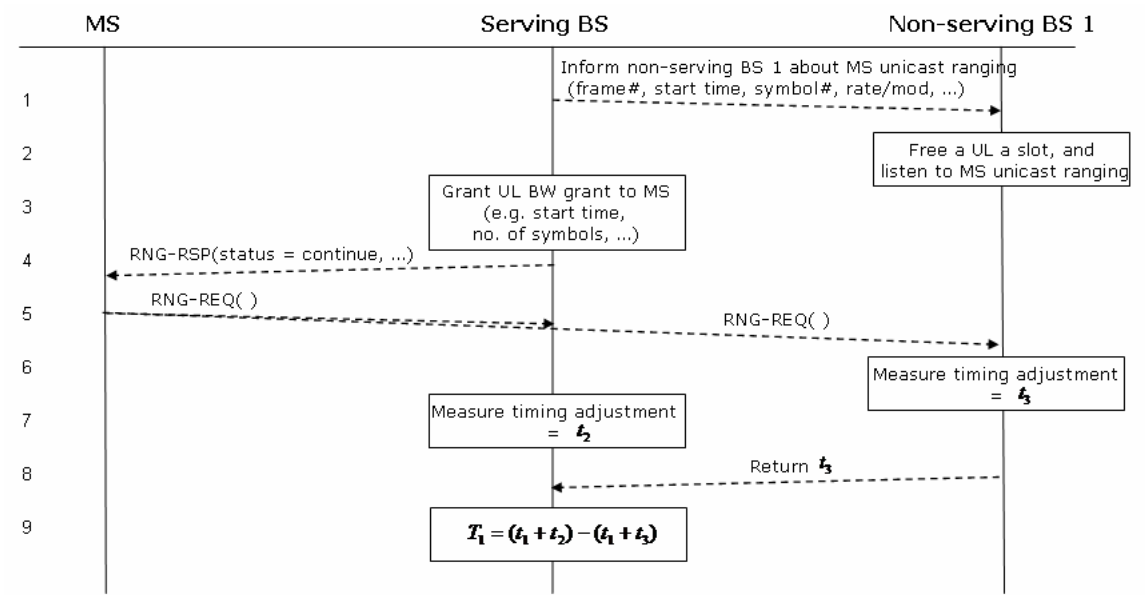

Figure I.5: U-TDOA Measurement Algorithm

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-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 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 Adjustment t_3
7. Serving BS measures Timing Adjustment t_2
8. Non-serving BS 1 returns t_3 to serving BS

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