Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**BS to BS Time Synchronization Support, for OFDMA PHY mode**
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Source(s)	Geunhwi Lim, Yong Chang, Seung Joo Maeng, Hong Sung Chang, JungWon Kim, TaeWon Kim Samsung Electronics Co. Ltd. geunhwi.lim@samsung.com David Ashkenazi david.ashkenazi@intel.com
Re:	
Abstract	**BS to BS Time Synchronization Support, for OFDMA PHY mode**
Purpose	Adoption of proposed changes into P802.16e /D4-2004
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1 Introduction

1.1 Time Synchronization

Time synchronization is required to operate with frequency reuse factor of 1 in the current OFDMA system. Time synchronization betweens BS can be usually achieved by GPS. But, GPS module is expensive and it's hard to receive GPS signals in indoors. Without GPS receiver, a small BS may achieve time synchronization with other GPS equipped BS via air signal such as Ranging. (Last contribution name is 'C80216e-04_205r1.doc')

1.2 Why Time Synchronization via AIR?

There are several mechanisms to get the time synchronization. NTP (Network Time Protocol) is a time synchronization mechanism via wired line. It has an advantage in that it can provide synchronized clock to all hosts and routers in the Internet. But, the nominal accuracy is not so precise enough for the BS time synchronization which requires higher precision than tens of microseconds.

The required time synchronization precision for reuse factor 1 is about 20 micro-seconds because the maximum time difference between two BS should be less than RTG which is about 70 micro-seconds. However, the precision provided by NTP is low tens of milliseconds on WANs, submilliseconds on LANs, and submicroseconds using a precision time source such as a cesium oscillator or GPS receiver. This means that even though we use LAN connection between BS we can't achieve the required precision. In the actual deployment, it may not possible to connect two BS with LAN cable.
Hence, we need a time synchronization mechanism via AIR. The best way do this is to use the CDMA ranging mechanism defined in the 802.16 standard.

1.3 Simulation Result of CDMA Ranging

The maximum resolution of the CDMA ranging is the sampling time which is calculated by dividing the Symbol time with FFT size. We can roughly get 0.09 microseconds of sampling time when the symbol time is 100 microseconds and the FFT size is 1024. In our simulation, the precision of the CDMA ranging is depends on the SNR. But, it shows that the average resolution is less than 1 microseconds. This value satisfies the required precision for the system operating with reuse factor of 1.
Figure 1 shows the result of the simulation. If the required ranging error is less than 10 symbol time then we can achieve this with the 99% probability. Actually the required error is a hundreds of symbol time. Figure 2 is the result with interference. This shows that the ranging mechanism provides 5 micro-seconds precision with a probability of 98% and we can also achieve the required precision when the interference exists.

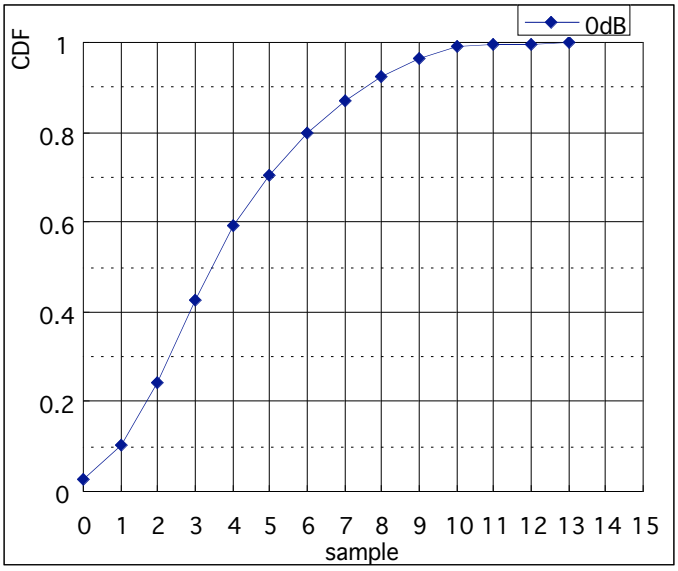

Figure 1. Simulation Result of CDMA Ranging Precision (0dB)

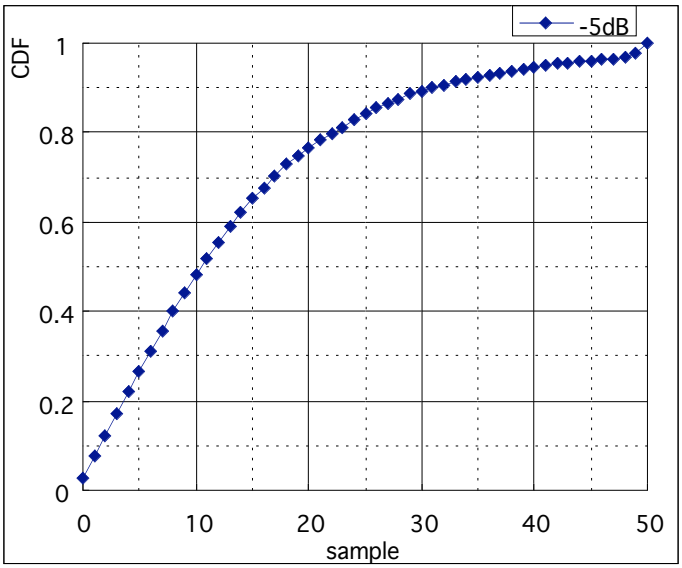

Figure 2. Simulation Result of CDMA Ranging Precision (-5dB)

1.4 Problem 1

Because the BS should periodically calibrate the internal clock to maintain the time synchronization, BS should periodically perform ranging operation in MSS mode.
During this period, a BS may not provide service to all MSS attached to the BS itself. It's possible for a BS to provide service to MSS and perform periodical ranging simultaneously if the BS is equipped with two air interfaces, one for MSS and the other for ranging. But, this configuration will increase the cost of BS.
Anyway, if a BS can't provide a service during certain period to MSS the BS should notify all MSS of the period. Otherwise, a MSS connected to the BS which performs ranging operation may consider the BS as dead and it may try to handover to another BS.

1.5 Remedy 1

Hence, in this contribution, we propose a TLV to indicate the time and duration when the BS performs clock calibration. And DCD message from the BS may include them.

1.6 Problem 2

A BS without GPS receiver may act as a serving BS for time synchronization if it has already synchronized with other GPS equipped BS. However, the accuracy of the synchronization provided by the BS would be lower than GPS equipped BS because of the synchronization error.

1.7 Remedy 2

Hence, we also propose a TLV to indicate hop count from the GPS equipped BS. This will provide the accuracy information of the time synchronization provided by the BS. The hop count should be set to 0 when a BS with GPS receiver provides the time synchronization information. And RNG_RSP message from the BS may include them.

2 Text Change

In page 86, add the following section

6.3.22 BS-BS Time Synchronization Operation

Time synchronization is required to operate with frequency reuse factor of 1 in the current OFDMA system. Time synchronization betweens BS can be usually achieved by GPS. But, GPS module is expensive and it's hard to receive GPS signals in indoors. Without GPS receiver, a small BS may achieve time synchronization with other GPS equipped BS via AIR signal such as Ranging.

Because the BS should periodically calibrate the internal clock to maintain the time synchronization, BS should periodically perform ranging operation in MSS mode. During this period a BS which has only one RF interface can't serve MSS which is connected to the BS. ~~and all MSS attached to the BS should not access the BS during the period.~~
Hence, DCD message from a BS may include TLV to indicate the time and duration when the BS performs clock calibration.

A~~n~~ BS without GPS receiver may act as a serving BS for time synchronization if it has already synchronized with other GPS equipped BS. However, the accuracy of the synchronization provided by the BS would be lower than GPS equipped BS because of the synchronization error.
Hence, ranging message may include TLV to indicate the accuracy of the time synchronization provided by the BS. The number of hop information may be used by BS to discard the synchronization information.

6.3.18.1 BS-BS Time Synchronization Operation Scenario

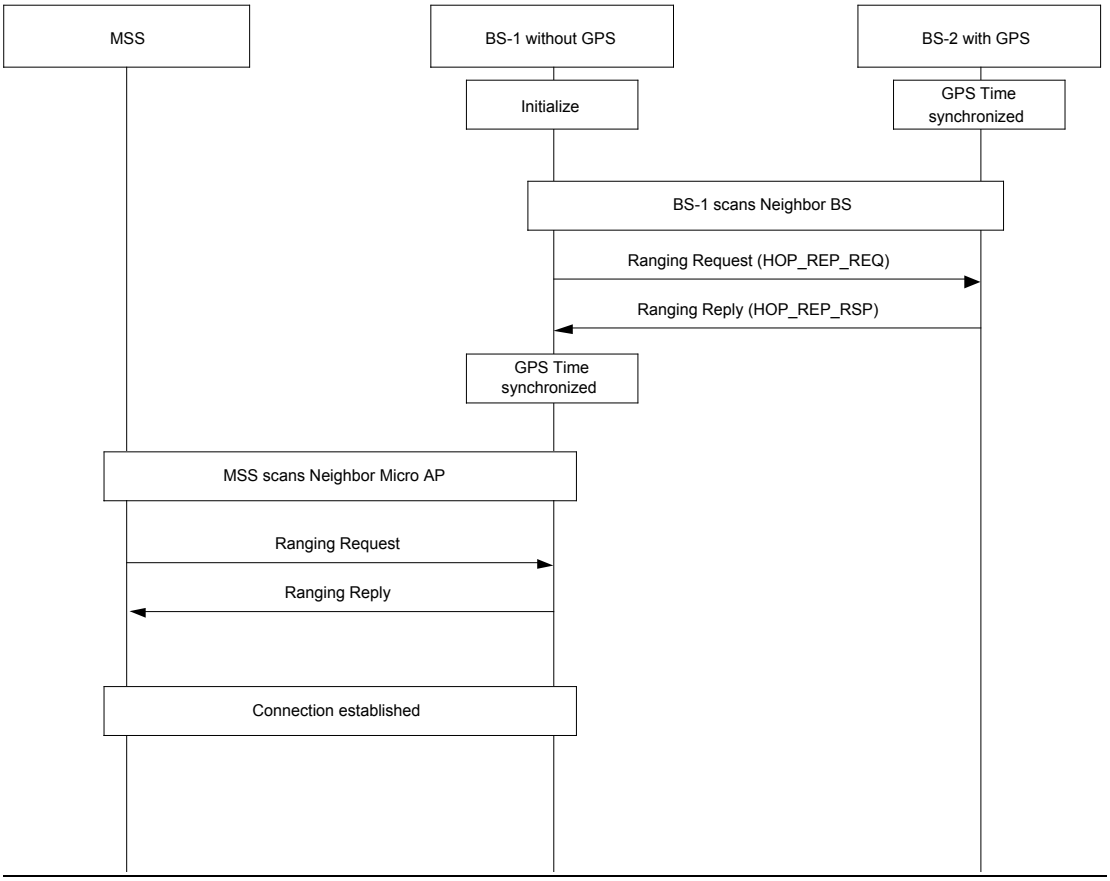

Figure 1 Initial BS-BS Time Synchronization

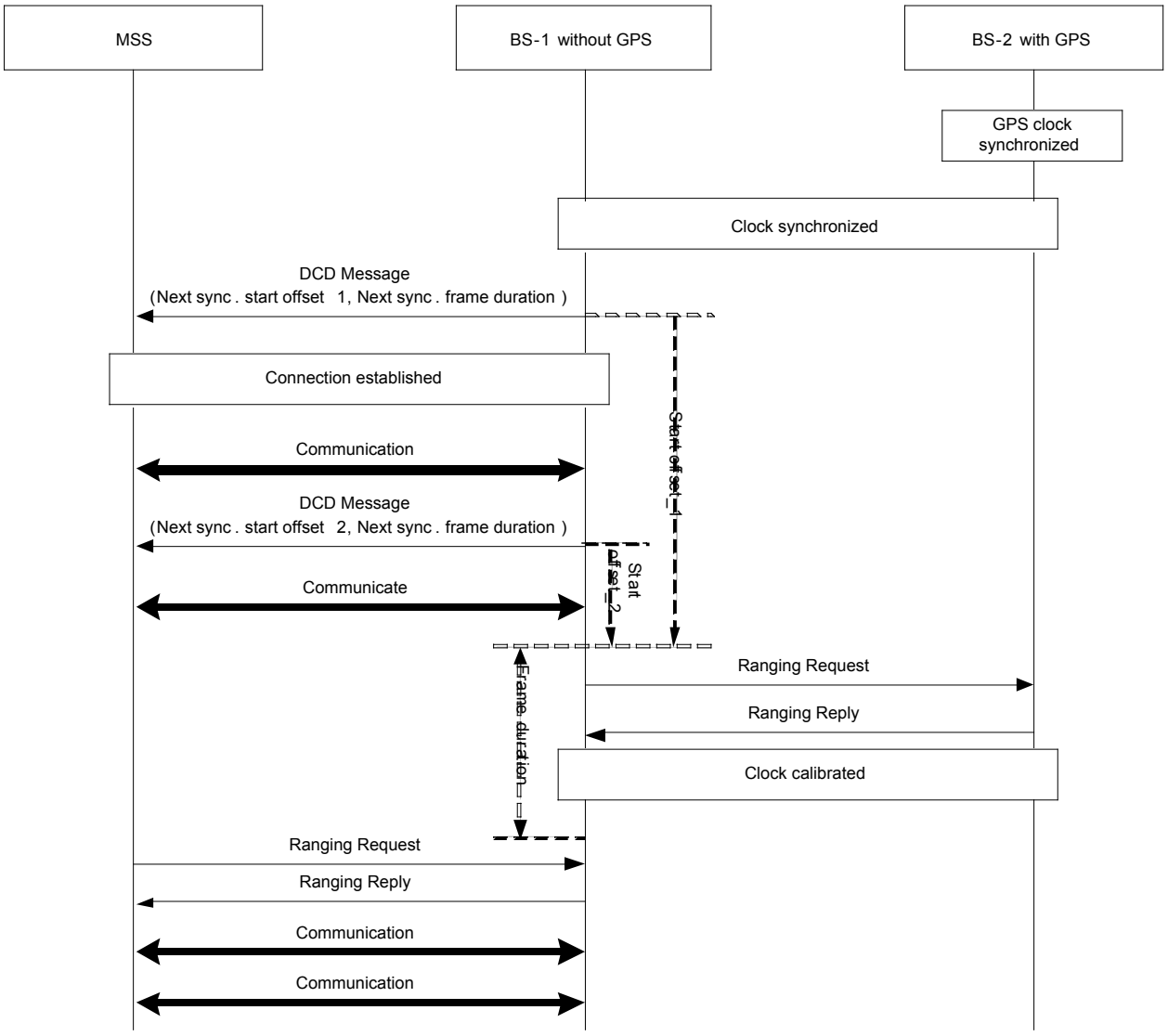

Figure 2 Periodic BS-BS Time Synchronization

In page 182, add the following section

11.4.1 DCD channel encodings

[Add to Table 356:]

Table 356a—DCD channel encoding

Name	Type	Length	Value	Scope
Time Synchronization Information	16	3	MSB 16 bits: This value indicates the Start Offset in frame unit of Next Synchronization start frame. LSB 8 bits: This value indicates the duration in frame unit ~~number of frames for~~of Next Synchronization phase All MSS connected to the BS should not transmit any signal to the BS during the synchronization.	OFDMA

In page 106, add the following section

11.7 REG-REQ/RSP TLVs for Time Synchronization

[Add the following rows to table 362:]

Table 362a—RNG-REQ Message Encodings

Name	Type	Length	Value	Scope
Time Synchronization Hop Report Request	21	1	1 = Hop Report Request ~~Time error report request~~	OFDMA

[Add the following rows to table 365:]

Table 365a—RNG-RSP Message Encodings

Name	Type	Length	Value	Scope
Time Synchronization Hop Report Response	21	1	BS may send this TLV in the respond of Hop Report Request. The value indicates the number of synchronization hops from GPS synchronized BS. The GPS equipped BS should send the value of ~~0~~1. The BS which does not have synchronized clock will return the value of 0.	OFDMA