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Re:	Task Group Review of IEEE 802.16e-03/07r3
Abstract	This contribution is to propose a modification to the length of the initial ranging transmission for IEEE 802.16 OFDMA.
Purpose	Task group approval of the modification.
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Short Initial ranging Transmission for IEEE 802.16 OFDMA

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Introduction

This document is to propose a modification to the initial ranging transmission in IEEE 802.16 OFDMA to improve the initial ranging performance.

Problem Statement

Arrival timings of initial ranging signals at a BS are not subject to be aligned with the OFDM symbol timing at the BS. The only information each SS under initial ranging has is the received downlink OFDM symbol timing, which the initial ranging signal is to be aligned with. Therefore, the initial ranging signals from the SS's close to the BS arrive at the BS with little timing offset while the initial ranging signals from the outermost SS's on the cell boundary arrive at the BS with a timing offset equal to the round trip delay. The current draft specifies the initial ranging transmission to last two OFDM symbol times by repeating itself without phase discontinuity as shown in Figure 1 in order to guarantee a full continuous-phase signal over the intended OFDM symbol epoch[1] for successful detection and timing offset estimation of the received initial ranging transmission.

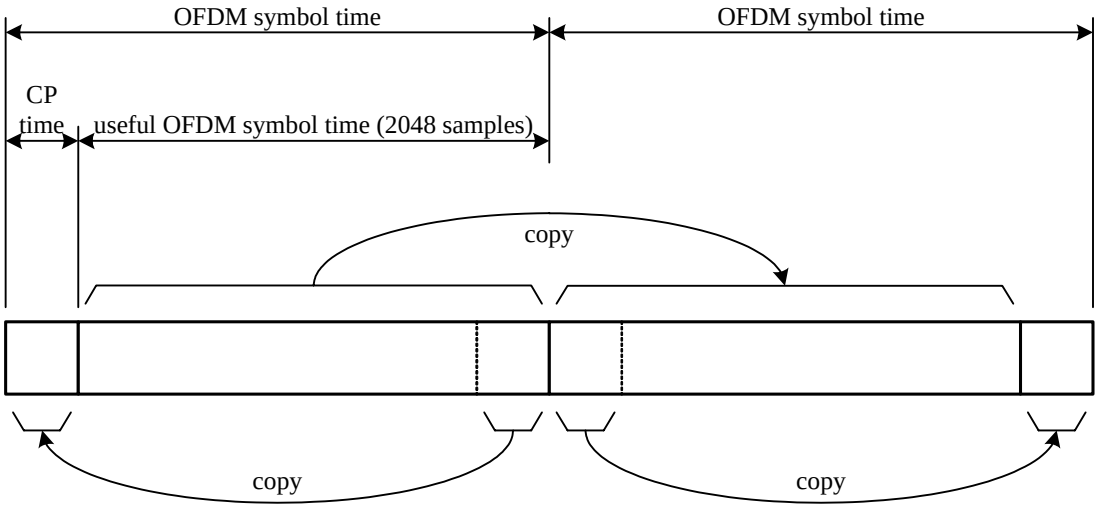

Figure 1–Initial ranging transmission for IEEE 802.16 OFDMA in the current draft

Figure 2 shows a favorable example, where the initial ranging transmissions from different SS's are either modulated with different ranging codes or separated by more than an OFDM symbol time. The RNG-A, RNG-B, and RNG-C in Figure 2 respectively denote the initial ranging transmissions from SS's A, B, and C. If we denote the index of the intended OFDM symbol epoch for an initial ranging transmission RNG-B of interest by *k* as in Figure 2, the ranging code and timing offset of RNG-B can be successfully detected in the *k*th OFDM symbol epoch without incurring interference to other uplink transmissions. However, the portions of a initial

[1] An SS randomly chooses success two OFDM symbol epochs within the data region allocated for initial ranging. Denoting them as the *k*th and (*k*+1)st OFDM symbol epochs for an integer *k*, In this document, the "intended OFDM symbol epoch" denotes the *k*th OFDM symbol epoch at the BS. Note that an SS can only expect that the portion of the signal arriving at the BS during the *k*th OFDM symbol epoch is guaranteed to be successfully detected since the initial ranging signal ends before the end of the (*k*+1)st OFDM symbol epoch due to the path delay between the BS and the SS, for which we denote the *k*th OFDM symbol epoch as "intended."

ranging transmission in the (*k*–1)st and the (*k*+1)st OFDM symbol epochs results in interferences to them, especially ranging transmissions. In the case when the round trip delay is less than a half of an OFDM symbol time, which would be typical in most practical cases, the long but incomplete portion in the (*k*+1)st OFDM symbol epoch can significantly degrade the ranging performance of the system.

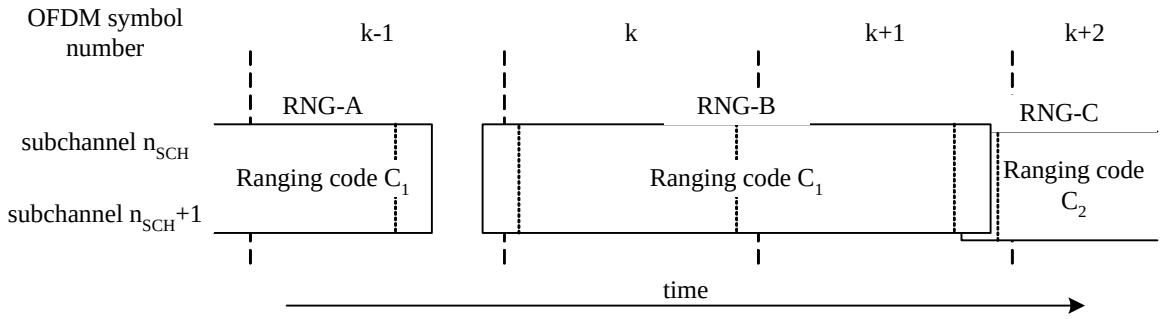

Figure 2–Example of disjoint initial ranging transmissions

Let us consider the example in Figure 3, where three different SS's initiate initial ranging at three successive OFDM symbol epochs with an identical ranging code. Ideally, all three initial ranging transmissions should be successfully detected since the SS's have chosen three different epochs. However, with the current design of initial ranging transmission, the incomplete portions of RNG-B and RNG-C in the (*k*+1)st and (*k*+2)nd OFDM symbol epochs degrade the detection of RNG-C and RNG-D, respectively.

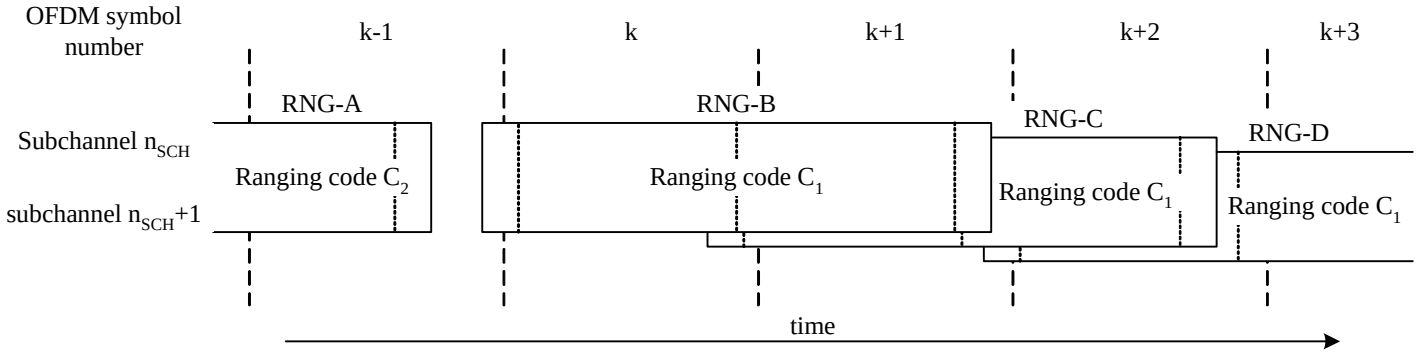

Figure 3–Example of successive initial ranging transmissions adjacent in time

Proposed Initial ranging Transmission for OFDMA

Unlike the preceding portion of the RNG-B in the (*k*–1)st OFDM symbol epoch, the portion of RNG-B in the (*k*+1)st OFDM symbol epoch can be shortened to reduce the interference to other uplink transmissions. In order to guarantee a complete continuous-phase signal during the intended OFDM symbol epoch at the BS, the length of the initial ranging transmission has only to be $T_s + T_{off\_max}$, where T_s denotes the OFDM symbol time and T_{off_max} is not smaller than the maximum round trip delay between the BS and an SS within the cell. The length of the initial ranging transmission is limited to $2T_s$. Figure 4 shows the proposed initial ranging transmission for OFDMA. This short initial ranging transmission scheme also reduces the amount of resources required for initial ranging by half, which is another important advantage. Reversely speaking, this also means that employing the proposed short initial ranging transmission doubles the number of detectable initial ranging transmissions.

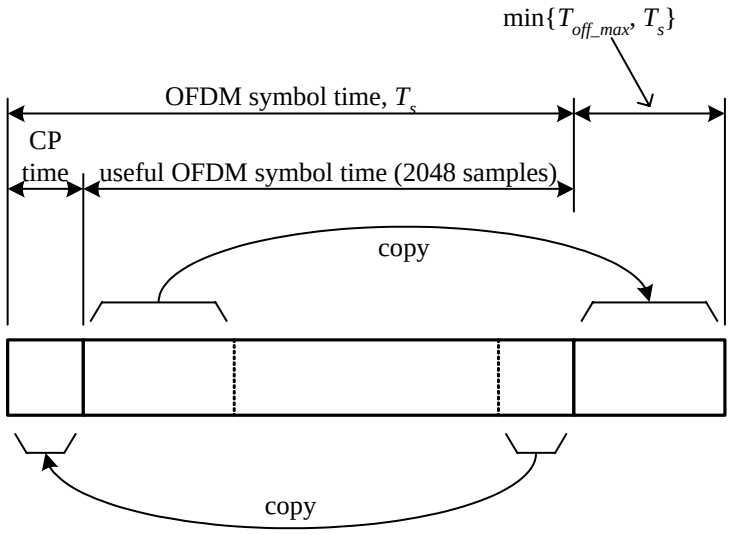

Figure 4–Proposed initial ranging transmission for OFDMA

We can consider three means to inform all the SS's in a cell of the value of T_{off_max}: First, we can define another TLV encoded DCD channel information on T_{off_max}; Second, T_{off_max} can be replaced with TTG since TTG is larger than the maximum round trip delay of the cell; Third, we can define another format of Initial Ranging Information Element in UL-MAP to deliver information on T_{off_max}.

Proposed Text Changes

One of the following three proposals could be taken for the proposed short initial ranging transmission:

Proposal #1:

Replace Figure 128bc with the following:

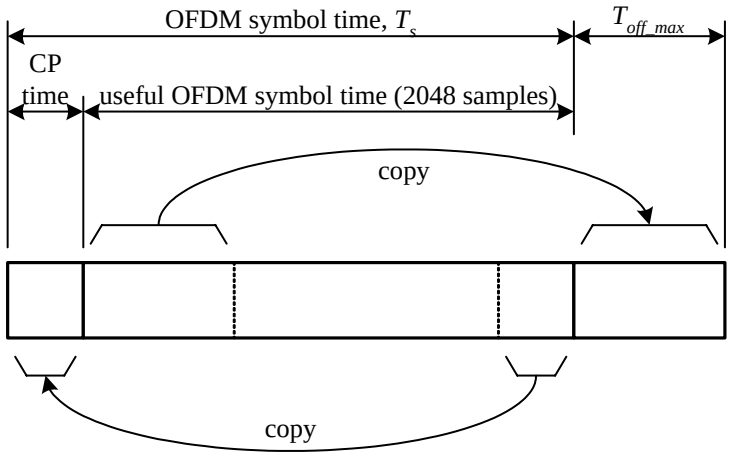

Figure 128bca–Proposed initial ranging transmission for OFDMA

and delete the second and the third sentences in 8.5.7.1 as follows:

The initial- ranging transmission shall be used by any SS that wants to synchronize to the system channel for the first time. ~~An initial-ranging transmission shall be performed during two consecutive symbols. The same ranging code is transmitted on the ranging channel during each symbol.~~ A time-domain illustration of the initial- ranging transmission is shown in Figure 128bca.

Also add the following row to Table 124:

Table 124–DCD channel encoding

Name	Type (1 byte)	Length	Value (variable length)	PHY scope
MAX_DLY	15	1	T_{off_max} = (MAX_TOFF + 1) × 10 OFDM sample times	OFDMA

Proposal #2:

Replace Figure 128bc with the following:

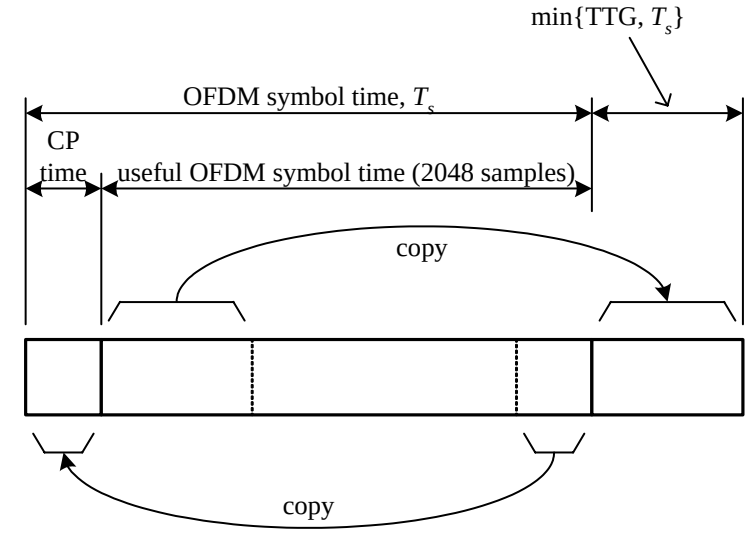

Figure 128bcb–Proposed initial ranging transmission for OFDMA

and delete the second and the third sentences in 8.5.7.1 as follows:

The initial- ranging transmission shall be used by any SS that wants to synchronize to the system channel for the first time. ~~An initial-ranging transmission shall be performed during two consecutive symbols. The same ranging code is transmitted on the ranging channel during each symbol.~~ A time-domain illustration of the initial- ranging transmission is shown in Figure 128bcb.

Proposal #3:

Replace Figure 128bc with Figure 128bca and delete the second and the third sentences in 8.5.7.1 as follows:

The initial- ranging transmission shall be used by any SS that wants to synchronize to the system channel for the first time. ~~An initial-ranging transmission shall be performed during two consecutive~~

~~symbols. The same ranging code is transmitted on the ranging channel during each symbol.~~ A time-domain illustration of the initial~~-~~ ranging transmission is shown in Figure 128bca.

Also change Table 116bt as follows:

Table 116bt–OFDMA UL-MAP Information Element format

Syntax	Size	Notes
UL-MAP_Information_Element() {		
CID	16 bits	
UIUC	4 bits	
if (UIUC == 4) {		
CDMA_Allocation_IE()	52 bits	
} else if (UIUC == 12) {		
Initial Ranging IE ()	36 bits	
} else if (UIUC == 15) {		
Extended UIUC dependent IE	variable	Power_Control_IE() or AAS_UL_IE()
} else {		
OFDM Symbol offset	9 bits	
Subchannel offset	5 bits	
Boosting	2 bits	00: normal (not boosted); 01: +6dB; 10: .6dB; 11: not used.
No. OFDM Symbols	9 bits	
No. Subchannels	5 bits	
Reserved	~~2~~6 bits	
}		
}		

and insert the following between 8.5.5.3.1 and 8.5.5.3.2:

8.5.5.3.2 Initial Ranging Information Element format

Table 116bua defines the UL-MAP_IE to informa all SS's in the cell of the initial ranging transmission parameters. This IE is identified by UIUC = 12.

OFDM Symbol offset

The offset of the OFDM symbols in which the data region allocated for initial ranging starts. The offset value is defined in units of OFDM symbols and is relevant to the Allocation Start Time field given in the UL-MAP message.

Subchannel offset

The lowest index OFDMA subchannel allocated for initial ranging transmissions, starting from subchannel 0.

No. OFDM Symbols

The number of OFDM symbols that are allocated for initial ranging transmissions.

No. Subchannels

The number of OFDMA subchannels with subsequent indexed, allocated for initial ranging transmissions.

MAX_DLY

The number of additional OFDM samples that are circular duplication in initial ranging transmission as specified in Figure 128bca. The value of T_{off_max} is defined by T_{off_max} = (MAX_TOFF + 1) × 10 OFDM sample times.

Table 116bua–Initial Ranging Information Element format

Syntax	Size	Notes
Initial_Ranging_IE() {		
OFDM Symbol offset	9 bits	
Subchannel offset	5 bits	
No. OFDM Symbols	9 bits	
No. Subchannels	5 bits	
MAX_DLY	8 bits	T_{off_max} = (MAX_TOFF + 1) × 10 OFDM sample times
}		

References

[1] IEEE Std 802.16-2001, “Part 16: Air Interface for Fixed Broadband Wireless Access Systems.”

[2] IEEE Std 802.16a™-2003, “Part 16: Air Interface for Fixed Broadband Wireless Access Systems – Amendment 2: Medium Access Control Modifications and Additional Physical Layer Specifications for 2–11 GHz.”

[3] IEEE 802.16e-03/07r3, “Part 16: Air Interface for Broadband Wireless Access Systems – Amendment 4: Mobility Enhancements.”