Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	Clarification on [4, 8, 16] Midamble Repetition Interval
Date Submitted	**2005-05-03**
Source(s)	Lei Wang, Cygnus Communications Dorin Viorel, Wi-LAN Ron Murias, Wi-LAN Jagan Seshadri, Wi-LAN Voice: +1-403-207-6479 Fax: +1-403-273-5100 E-mail: dviorel@wi-lan.com
Re:	Response to the call for comments IEEE 802.16-2004/Cor1-D2 Corrigendum to IEEE 802.16-2004
Abstract	Midamble repetition intervals [4, 8] are not suitable for a fixed wireless access propagation environment, due to the lack of Doppler induced effects.
Purpose	Change the midamble repetition interval to the previous values [8, 16, 32].
Notice	This document has been prepared to assist IEEE 802.16. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.
Release	The contributor grants a free, irrevocable license to the IEEE to incorporate material contained in this contribution, and any modifications thereof, in the creation of an IEEE Standards publication; to copyright in the IEEE's name any IEEE Standards publication even though it may include portions of this contribution; and at the IEEE's sole discretion to permit others to reproduce in whole or in part the resulting IEEE Standards publication. The contributor also acknowledges and accepts that this contribution may be made public by IEEE 802.16.
Patent Policy and Procedures	The contributor is familiar with the IEEE 802.16 Patent Policy and Procedures <http://ieee802.org/16/ipr/patents/policy.html>, including the statement "IEEE standards may include the known use of patent(s), including patent applications, provided the IEEE receives assurance from the patent holder or applicant with respect to patents essential for compliance with both mandatory and optional portions of the standard." Early disclosure to the Working Group of patent information that might be relevant to the standard is essential to reduce the possibility for delays in the development process and increase the likelihood that the draft publication will be approved for publication. Please notify the Chair <mailto:chair@wirelessman.org> as early as possible, in written or electronic form, if patented technology (or technology under patent application) might be incorporated into a draft standard being developed within the IEEE 802.16 Working Group. The Chair will disclose this notification via the IEEE 802.16 web site <http://ieee802.org/16/ipr/patents/notices>.

Clarification on [4, 8, 16] Midamble Repetition Interval

Dorin Viorel / Ron Murias / Jagan Seshadri - Wi-LAN Inc.
Lei Wang – Cygnus Communications, Inc.

1 Statement of the problem

Midamble repetition interval set of {8, 16, 32} was changed to {4, 8, 16} in Cor1/D1 as a result of the resolution to Comment #139 (Commentary database 80216-04_20r10). The change to the repetition interval was added by the group for the following reason:
"In addition, it is recommended to replace the set of midamble spacings of {8,16,32} with {4,8,16}. The value of 32 is not very practical, while the value of 4 may be useful in very high Doppler spread scenarios."

We dispute the assertion that "the value of 32 is not very practical." The use of a midamble may sometimes be necessary in a fixed link, but it would be rare that the channel would be changing quickly enough to require the use of a very small repetition interval. Therefore the interval of 32 would be more useful for fixed links with relatively slowly-varying channels than an interval of 4. Removing the interval of 32 doubles the minimum amount of overhead required should midambles be required or useful.

The repetition interval of 4, with its associated high overhead, would only be used for links in which the SS is highly mobile. Such links are beyond the scope of the 802.16-2004 standard to which this Corrigendum applies as the standard is specifically designed for "Fixed Broadband Wireless Access" (not mobile) links. Further, changing the repetition interval set to accommodate mobility is beyond the scope of the Corrigendum since it alters decisions made in the creation of the standard rather than implementing a correction. Therefore the set of repetition intervals should remain as {8, 16, 32}.

2 Justification

We consider a mobile user moving with a given speed (<= 350 km/h) and we evaluate the number of OFDM256 symbols that can be sent before channel estimates need to be refreshed, in order to assess the suitable number of midambles for a mobile environment. We consider a 5.8 GHz link which would produce the highest refreshment rates, though being a conservative case.

Based on [4], the channel estimate refresh rate is the reciprocal of the channel coherence time, T_c , given as:

$$T_c = \sqrt{\frac{9}{16 \cdot \pi \cdot {f_m}^2}} \qquad \text{Equation 2-1}$$

where f_m is the maximum Doppler shift [Hz]:

$$f_m = \frac{v \cdot f_c}{c}$$ Equation 2-2

where f_c is the carrier frequency [Hz].

At 350km/h (97.2 m/s) , the highest Doppler shift will be encountered at the 5.8GHz carrier frequency, resulting in f_m = 1880Hz. From this, the coherence time is 0.225 ms, which is how long the channel estimate stays valid before needing to be refreshed. *This can be expressed as a channel refresh rate of 4444 Hz.*

At 110km/h (30.5 m/s) , the highest Doppler shift will be encountered at the 5.8GHz carrier frequency, resulting in f_m = 590Hz. From this, the coherence time is 0.716 ms. *This can be expressed as a channel refresh rate of 1397 Hz.*

We now consider an OFDM256 signal used having a nominal channel bandwidth of 3.5 MHz.

The related sampling frequency (as stated in [2], section 8.3.2.1 and section 8.3.2.2) , is Fs=4 MHz
The related subcarrier spacing is:

$$\Delta f = \frac{F_s}{N_{FFT}} = \frac{4*10^6}{256} = 15625Hz$$ Equation 2-3

Based on the Equation 2-2, the related OFDM256 useful symbol time, for BW=3.5 MHz, is:

$$T_b = \frac{1}{\Delta f} = 64\mu s$$ Equation 2-4

For a conservative case, we consider CP=1/4 (heavy multipath fading content). Accordingly, the OFDM256 symbol time is:

$$T_s = T_b + T_g = 80\mu s$$ Equation 2-5

A mobile user moving with 350 km/h will experience a fast fading notch at every R_{350} OFDM symbols

$$R_{350} = \frac{0.225*10^{-3}}{80*10^{-6}} = 2.81 \text{ symbols}$$ Equation 2-6

A mobile user moving with 110 km/h will experience a fast fading notch at every R_{110} OFDM symbols

$$R_{110} = \frac{0.716*10^{-3}}{80*10^{-6}} = 8.95 \text{ symbols}$$ Equation 2-7

The worst scenario is represented by a user moving at 350 km/h, using a 5.8 GHz radio communication based on an OFDM256 signal (BW=3.5 MHz), with CP=1/4. Such an user will require new channel estimates able to correct fading notches occurring at every 2.8 OFDM symbols.

3 Proposed solution

A fixed wireless access user will not be subject to any Doppler induced fading. Therefore midamble repetition rates of 4 or 8 are not required for this kind of propagation environment.

In the fixed wireless case, the following situations could impact the RF propagation channel:

A. Changes in the radio refractivity index due to changes appeared in the atmospheric humidity and pressure along the main propagation path. These changes are in the range of higher than 0.1s, being considered slow fading as compared with the symbol duration. These changes impact both the LOS and NLOS types of links. Accordingly the required refreshment rate would be >=0.1s, which generates a fade notch at every 1250 symbols (5.8 GHz links).

B. Changes appeared in the diffraction edge region, which may impact the NLOS types of link. Under this particular case, the speed of wind could cause changes in the oscillating speed of leaves, if the diffraction edge region contains a tree. Under this particular case, which would deliver a suboptimal link availability, a 100 km/h wind speed may create an oscillation speed around 27 Hz. Such a value is 164. times lesser than the refreshment rate requested by a user moving with 350 km/h and 51 times lesser than an user moving with 110 km/h. Though a 100 km/h speed wind would generate fades for a NLOS link based on a diffraction region containing trees at every 448 symbols (5.8 GHz links). This type of fading is also considered a slow fading. The same kind of calculation would apply to the diffraction regions where moving vehicles would intersect the radio link.

C. The rain falls would mainly impact the radio links above 10 GHz, the impact on the lower frequency ranges would have being minimal.

Based on the fixed wireless propagation cases described at A, B and C cases, there is no physical justification for requesting a midamble repetition rate of 4 for fixed wireless links. This increases in an unjustified way the overhead.

Accordingly, we propose to revert back to the previous midamble repetition rate structure of {8, 16, 32}. To be noted that even a midamble repetition rate of 32 would provide a suitable refreshment rate.

4 Specific text changes.

Undo all changes altering the set of repetition intervals. Specifically:

Page 65, line 40:
Change the 'Midamble Repetition Interval' field in Table 228 as indicated:
0b00: Preamble only
0b01: Interval 9: Midamble after every 8 data symbols
0b10: Interval 17: Midamble after every 16 data symbols
0b11: Interval 33: Midamble after every 32 data symbols

Page 66, line 50:

Change the 'Midamble Repetition Interval' field in Table 245 as indicated:
0b00: Preamble only
0b01: Interval 9: Midamble after every 8 data symbols
0b10: Interval 17: Midamble after every 16 data symbols
0b11: Interval 33: Midamble after every 32 data symbols

5 Reference.

[1] T.S. Rappaport: “Wireless Communications: Principles and Practice (2nd Edition)”, Prentice Hall, 2001
[2] working document IEEE 802.16-2004/Cor1-D2, 2005-04-04.
[3] IEEE P802.16-REVd/D5-2005, May 2004
[4] “Scalable OFDMA Physical Layer in IEEE 802.16 WirelessMAN”, Intel Technology Journal, Volume 8, Issue 3, August 2004.
[5] R. Freeman: “RF Design for Telecommunications Systems”, Wiley and Sons, 1999

6 Appendix 1

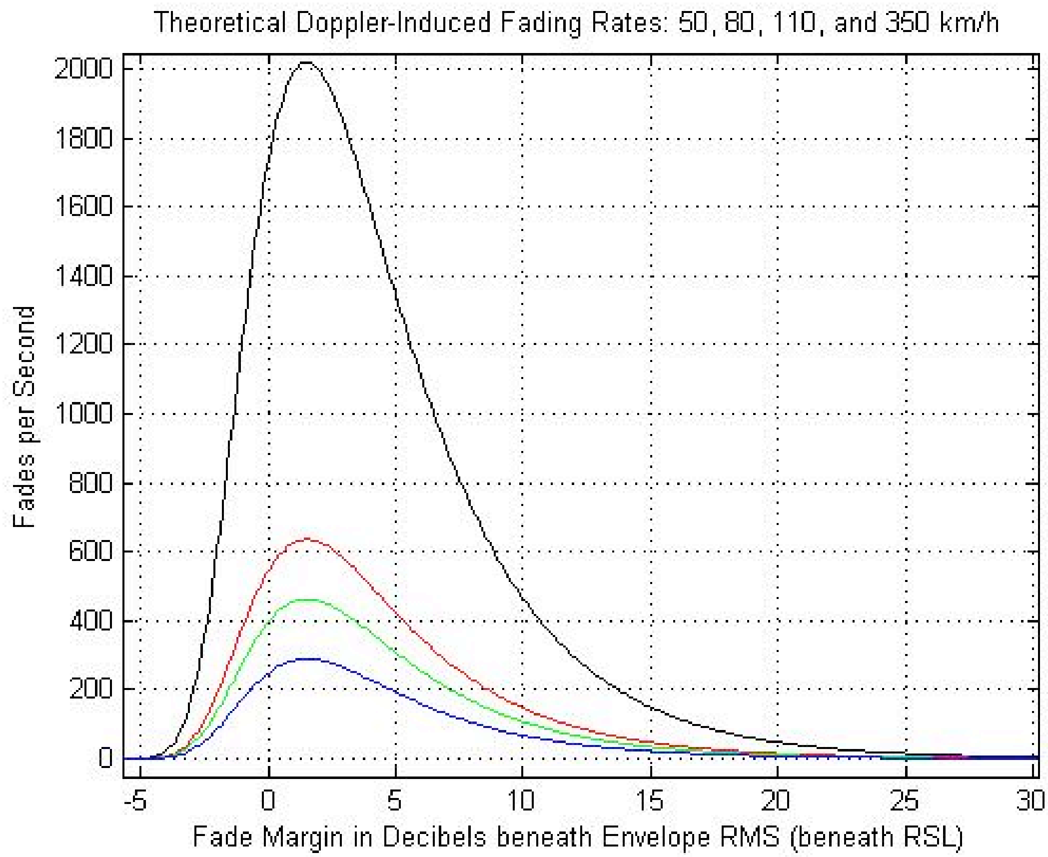

Figure 6-1. Number of Doppler induced fades per second for different speed rates.