IEEE P802.11
Wireless LANs

TGa Preamble Improvement Proposal

Date: November, 8, 1998

Author: Tal Kaitz and Naftali Chayat
BreezeCom
Atitim Technology Park, Bldg. 1, Tel-Aviv 61131, Israel
Phone: +972-3-645-6262
Fax: +972-3-645-6290
e-Mail: [talk naftalic]@breezecom.co.il

Abstract

In this submission we consider a modification to the proposed preamble structure as presented in the standard draft.

The proposal affects both the channel estimation section and the rate signaling section. The channel estimation section expanded to include three 3.2 uSec sections instead of two. Fine frequency estimation is performed by channel estimation section. It is verified that the fine frequency estimation thus enjoys a better signal to noise ratio.

The robustness of the rate-signaling field is examined and is shown to be the limiting factor in the 6Mb/s mode. Two solutions are presented to alleviate this problem. The first considers using a dedicated OFDM symbol containing rate and duration information. The second solution involves a different phase assignment scheme for the QPSK symbols in the rate field.

I. Introduction

The structure of the preamble section, as of the September 98 meeting, is shown in figure 1.

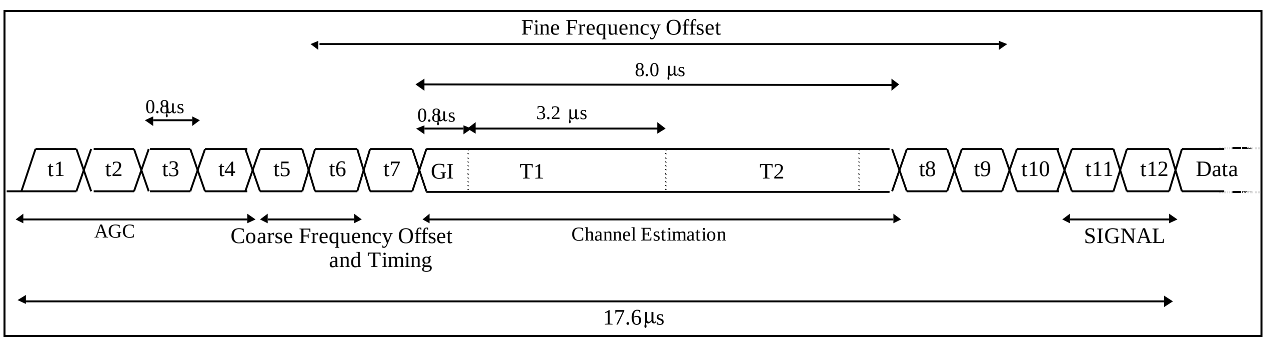

Figure 1

The main functions of the preamble are

- AGC tuning performed by t1…t3.
- Coarse frequency estimation performed by t5 and t6.
- Fine frequency estimation performed by t6 and t9
- Channel estimation by T1 and T2.

This submission is organised as follows: In section II we consider and demonstrate an improvement to the channel estimation section. In section III, we show that the lack of robustness of the rate-signaling field is the limiting factor in low rate transmission. Two solutions are suggested. In section IV, we consider several options for combining the modifications of sections II and III. Section V concludes this submission.

II. Channel estimation section

The functions of the fine frequency offset estimation and channel estimation can be unified to allow a more efficient preamble structure. This is shown in figure 2.

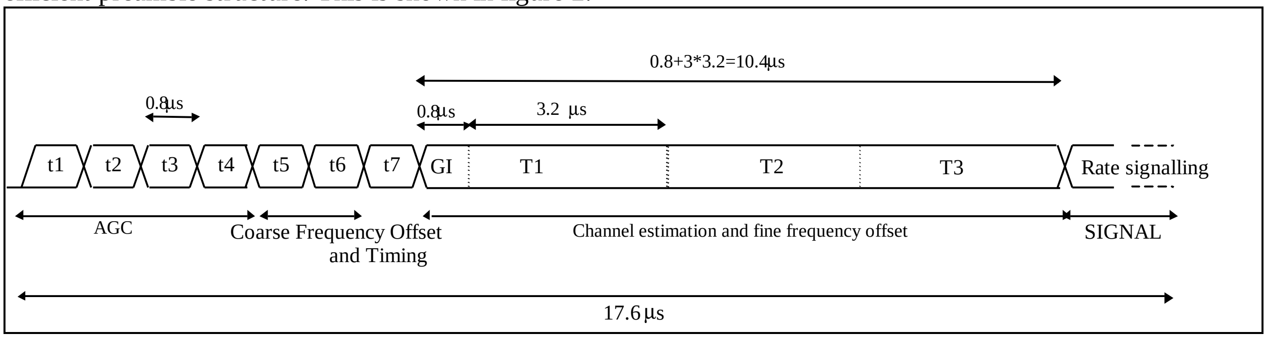

Figure 2

The channel estimation section includes a 0.8 uSec guard interval and three long 3.2 usec segments. Note that the overall length up to the beginning of the rate signaling section is the same as in the current proposal. Next, we consider the operation of channel estimation and fine frequency estimation.

Channel estimation

Channel estimation can performed as before by averaging the three identical segments. Since the estimation process now involves three segments instead of two the estimation is more robust.

Fine frequency estimation

Fine frequency estimation can be performed by comparing the phases of the samples in the T1 segment to that of the T3 segment.

Now we compare the fine frequency estimation schemes in terms of signal to noise ratio.

First, let us consider the general case in which frequency offset estimation is performed by comparing the phase of two identical segments. Let T denote the duration of each segment and let L denote the spacing between the segments. Then the signal to noise ratio is proportional to:

$$SNR \propto L^2 T \, .$$

For the current proposal we have $T_1=0.8\ usec$ and L_1=4*0.8usec+8.0usec=12.2usec (The distance between t5 and t9 in figure 1). For the proposed scheme we have $T_2=3.2usec$ and L_2=2*3.2=6.4usec (The distance between T1 and T3 in figure 2). The ratio between the signal to noise ratio of the proposed method (SNR_2) to that of the current scheme (SNR_2) is given by:

$$\frac{SNR_2}{SNR_1} = \frac{L_2^2 T_2}{L_1^2 T_1} = 1.1 = 0.42dB \, ,$$

therefore the frequency estimation performance remains roughly same with a slight advantage to the new scheme.

Simualtion Results

a. Performance in AWGN

100 packets of 100 bytes each at 24Mb/s. Performance gain of about 0.8 dB at PER=0.1 is observed.

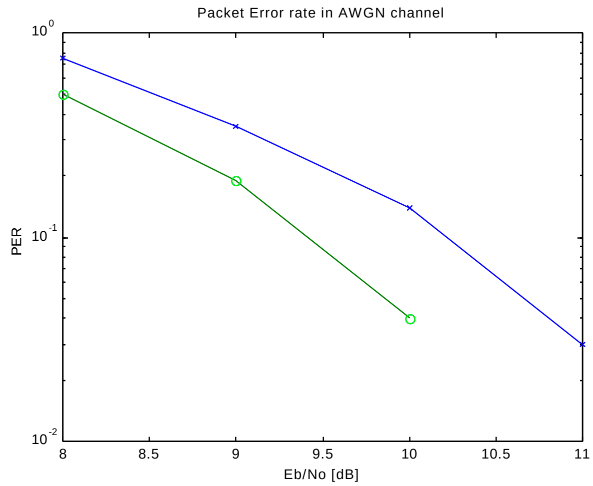

Figure 3

Legend: Blue- current proposal green-improvement

b. Performance in fading channels

100 packets of 100 bytes each at 24Mb/s at Trms=150 and 200 nsec. Performance gain of about 1dB can be achieved.

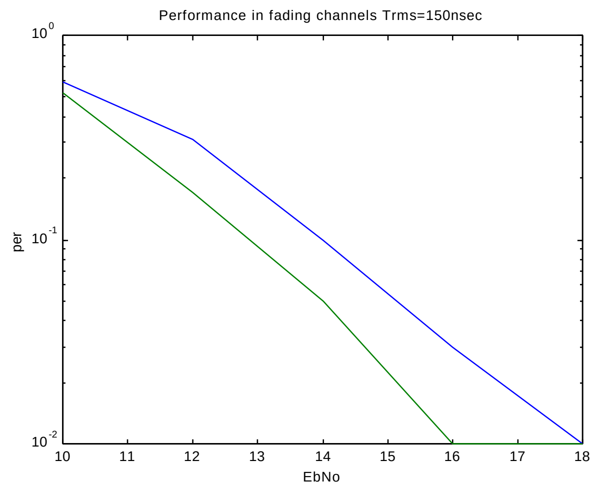

Figure 4

Legend: Blue- current proposal green-improvement

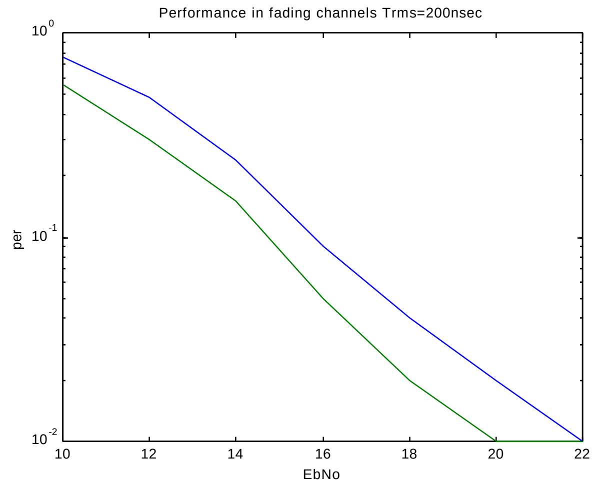

Figure 5

III. Rate Signaling Improvement

Motivation

The rate signaling method described in the standard’s draft is based on two QPSK modulated short 0.8 uSec sequences. The two sequences are shown in figure 1 as t11 and t12.

A fundamental point to note is that the signaling scheme should be at least as robust as the most robust modulation method. Otherwise, the packet error rate will be dominated by the error rate of the rate-signaling field.

In a set of simulation experiments performed by BreezeCOM, the robustness of the signaling scheme was evaluated. It was revealed that the proposed rate-signaling scheme is less robust then 6Mb/s BPSK in severe multipath conditions.

The results of one simulation experiment are shown in figure 3. This figure shows the error rates of the rate field and of the data frame as function of channel RMS length. Data rate is 6Mb/s (rate ½ BPSK) and the frame length is 100 bytes. 100 channels were simulated.

It can be observed that at Trms=600nSec, the error rate in the rate field is about three time higher than the frame error rate.

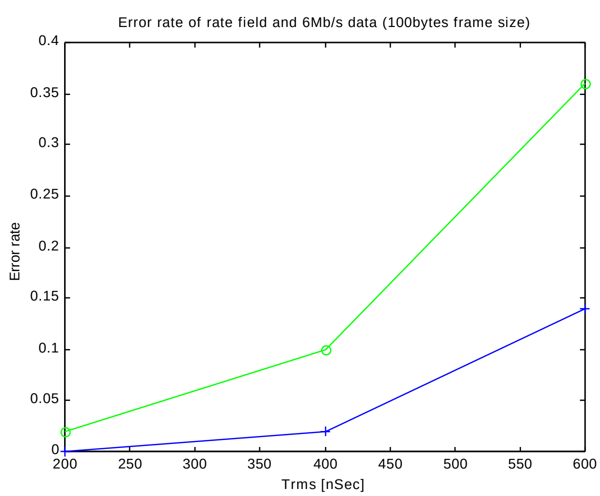

Figure 6

Legend : green circle – rate field error rate. Blue cross : Data frame error.

In the following two solutions are proposed. In the first, a dedicated OFDM symbol is added. In the second, the phase assignment scehme is modified to allow better detection of low rates.

1st solution

The proposed method is to use a dedicated BPSK OFDM symbol with a coding/modulation scheme similar to that of the data section. Thus 24 bit are availble. Out of the 24 bits, 4 are used for rate-signaling , 2 are used for random scrambling, 12 are used for duration signaling and 6 are dedicated for CRC.

The addition of a duration field will allow receiving units to assert a channel busy condition for the duration of the packet even if the unit is incapable to receive the PLCP header.

The data format is presented in table 1.

Bit location	Contents
0	Scrambler bit #0
1-4	Rate
5	Scrambler bit #1
6-17	Duration in OFDM symbols
18-23	CRC

Table 1

Scrambler bits #0 and #1 allow random scrambling of the OFDM symbol.

The CRC is an extended Hamming code (5 hamming bit parity). This code can detect up to three bit errors.

The interleaving scheme is the same as for the data section.

The encoding is a rate ½ k=7 convolutional code. Encoding is performed in a “tail-bite” fashion, in which the convoultional encoder registers are initialized with the *last* bits of the block. This allows for circular trellis termination.

Decoding the “tail-bite” coded block is performed as in the continuos case with the difference that the data fed to the Viterbi Algorithm (VA) is repeated in a circular manner. Several additional bits should be entered into the VA in order to overcome the unknown initial and final conditions of the trellis.

2nd solution

Let us consider the rate-signaling field in the current proposal. When the channel impulse response is long, some energy from adjacent symbols may leak into the rate signaling symbols (t11 and t12). If the impulse response is nearly minimum phase (that is, the energy is concentrated in the first taps) and timing estimation is correct then most of the distortion would be caused by previous symbols.

Considering the above, we can improve the robustness of the rate signaling in the 6Mb/s case. This is accomplished by assigning the 6Mb/s the phase sequence {0,0}. If the decoding is performed by comparing the phase of t11 and t12 to that of t10 than the channel effects will exactly cancel out and will not interfere with the detection process.
In a similar manner, other low rates can be assigned the phase sequences {0,exp(j*pi*k)} thereby increasing the reliability of the first 2 bits.

To demonstrate the effectiveness of this solution, we simulated the case of 6Mb/s and 12Mb/s under severe multipath conditions and compared the rate signaling error rate to that of 100 byte data packet. The results are shown in figure 2.

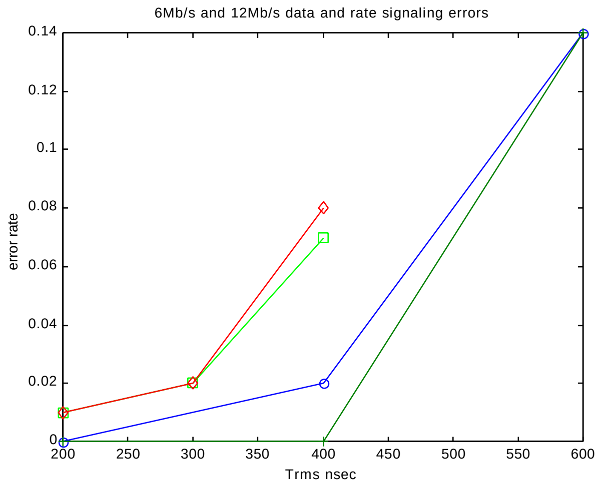

Figure 7

Legend: <u>6Mb/s</u> black cross rate error ; blue circle -data error;
<u>12Mb/s</u>: red diamond - rate error ; green square- data error

It was verified that almost in all the cases where an error rate occurred, a data error had also occur, hence errors in the rate field are not a limiting factor.

<u>IV. Combining the two modifications</u>

In this section how the modifications presented can be combined. We shall consider the four options listed below:

<u>Option A</u>: An improved channel estimation sequence and a dedicated OFDM signaling frame. This is shown in figure 8.
The advantages of this option are improved channel estimation, high robustness of the rate signal, additional **duration information available** to all station the can receive the lowest rate.

The disadvantage are the increase in preamble duration (20 uSec overall) and increase in processing complexity.

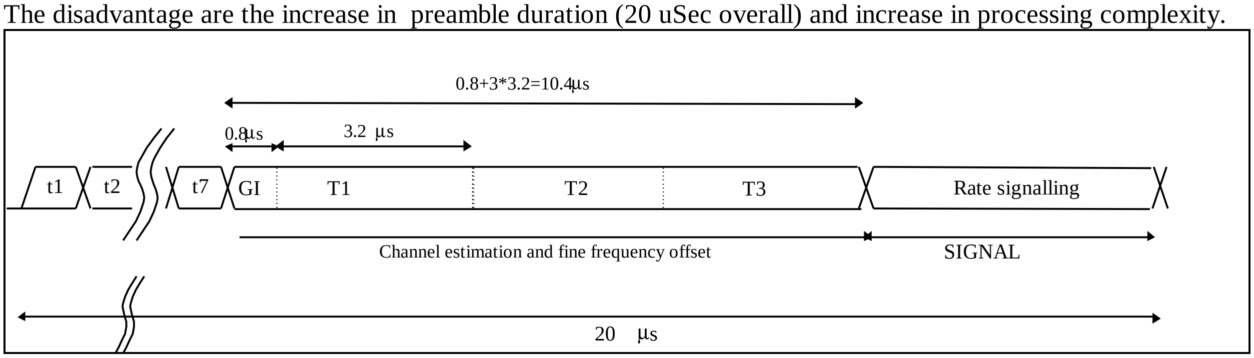

Figure 8

Option B: An improved channel estimation and QPSK modulated rate signaling, using the phase assignment suggested above. This is shown in figure 9. Note that an extra guard symbol is needed after the channel estimation.

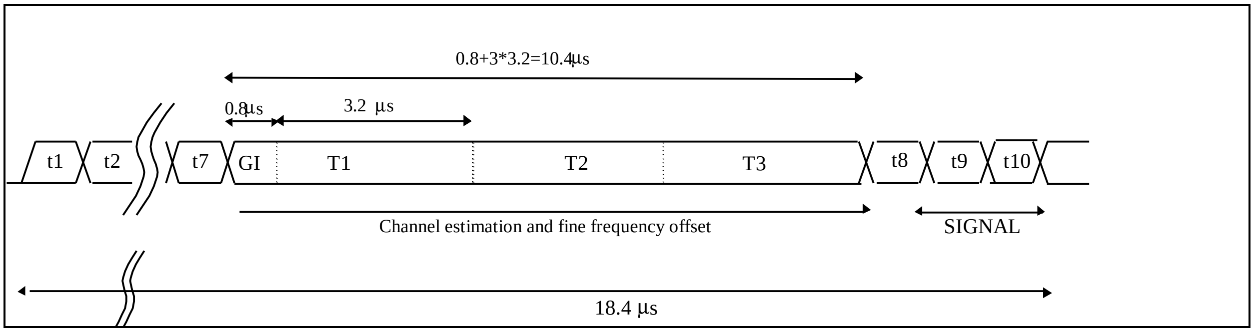

Figure 9

In this option the overall duration is only slightly increased (18.4 uSec overall relative to 17.6 usec in the current proposal).

Option C. Use the preamble structure of the current proposal and improve rate signaling by using the proposed phase assignments.

Option D. Use the current channel and frequency estimation and a dedicated OFDM symbol for rate signaling.

V. Conclusions

In this submission we discussed improvements to the channel estimation section and to the rate field.

The improvement to the channel estimation scheme is achieved by unifying the fine frequency estimation section with the channel estimation section. It was shown that this results in slightly improved signal to noise ratio for the frequency estimation. The improved channel estimation has an overall performance gain of 1dB in both AWGN and fading situation.

It was shown that the rate signaling is not robust enough for low rate transmissions. Two solutions were suggested. In the first solution, a dedicated OFDM scheme is added which conveys rate and time duration information. The second solution uses an improved set of phase assignments for the QPSK modulation.