Submission to IEEE P802.11 Wireless LANs

Title: **Range and Delay Comparison**

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Abstract

This submission compares the range and multi-path performance of the Harris, Lucent and Micrilor waveform proposals for the high rate 2.4 GHz PHY. The data for this submission was collected from the materials submitted to the committee in the January and March meetings. The intent was to generate a graph of range verses delay spread for each waveform at a specific packet error rate (PER) under the same transmit power, antenna gain, link loss exponents, and noise figures. A range comparison was chosen as opposed to a receiver sensitivity comparison because of the power amplifier output back off (OBO) required by each waveform is different. In order to hold the transmit power amplifier power dissipation constant the OBO must be considered for each waveform in a true link calculation. Unfortunately, from the way the data was generated for the comparison matrix, 20% PER was the only data point which was available for all waveforms. However, the 20% PER points does give a basis for relative comparisons between the waveforms with all other factors equal.

1. Introduction

This submission compares the range and multipath performance of the Harris, Lucent and Micrilor waveform proposals for the high rate 2.4 GHz PHY. The data for this submission was collected from the materials submitted to the committee in the January and March meetings. The intent was to generate a graph of range verses delay spread for each waveform at a specific packet error rate (PER) under the same transmit power, antenna gain, link loss exponents, and noise figures. A range comparison was chosen as opposed to a receiver sensitivity comparison because of the power amplifier output back off (OBO) required by each waveform is different. In order to hold the transmit power amplifier power dissipation constant the OBO must be considered for each waveform in a true link calculation. Unfortunately, from the way the data was generated for the comparison matrix, 20% PER was the only data point which was available for all waveforms. However, the 20% PER points does give a basis for relative comparisons between the waveforms with all other factors equal.

2. Procedure

The Eb/No performance of each waveform was compared in thermal noise only and in thermal noise at the RMS delay spread which resulted in 10% PER in no noise (Trms). Because of the way in which the data was generated for the 802.11 trade matrix, there is not comparative data at Trms for 10% PER in noise for all waveforms. So, 20% PER was selected as the common point for both thermal noise only and multipath plus thermal noise performance. One would have liked to have had 20% PER Eb/No numbers for each waveform at various delay spreads, however, due to the way in which the data way generated for the trade matrix, performance in noise at other than Trms was not necessarily available.

The Eb/No numbers were collected from the trade matrix and presentations given at the January and March meetings of the 802.11 for each waveform. The waveforms compared and associated references are shown in Table 2-1. Each proposal was evaluated at rates of 5 Mb/s and 10 Mb/s to give bounds on performance (highest rate and lowest rate). The performance at the 8 Mb/s rates offered by some of the proposals was taken as an intermediate rate and its performance should fall somewhere between the 5 Mb/s and 10 Mb/s performance curves. The tabulated Eb/No are shown in Table 2-3.

The link budget calculations were based on the parameters shown in Table 2-3 for each waveform. The link loss model assumed free space loss for the first 1 meter and then a loss exponent of 3.75. It is believed that this is representative of office and light industrial environments. Most all of the data collected on indoor propagation indicates loss exponents of between 2.5 and 4 or even 5, with the bulk of the data indicating exponents between 3.5 and 4.0 for indoor office and light industrial environments. Implementation loss was set at 0 dB. Although this is unrealistic, using 0 dB implementation loss across

the board keeps the playing field level since no data as to the susceptibility of each waveform to amplitude and phase balance, filtering effects, converter quantization, etc. was presented in the trade matrix.

Company	Waveform	Reference
Lucent	5 Mb/s (CMF Only)	IEEE802.11-98/99/140
Lucent	5 Mb/s (CMF+TSE+MS)	IEEE802.11-98/99/140
Harris	5.5 Mb/s (2,5)	IEEE802.11-98/47/140
Harris	5.5 Mb/s (2,10)	IEEE802.11-98/47/140
Harris	5.5 Mb/s (2,20)	IEEE802.11-98/47/140
Lucent	10 Mb/s (CMF+TSE+MS)	IEEE802.11-98/99/140
Micrilor	10 Mb/s	IEEE802.11-98/47/140
Harris	11 Mb/s (2,5)	IEEE802.11-98/47/140
Harris	11 Mb/s (2,10)	IEEE802.11-98/47/140
Harris	11 Mb/s (2,20)	IEEE802.11-98/117/140

Table 2-1 Waveform Comparisions and References

Waveform	Tx Power (dBm)	Antenna Gain (dBi)	Noise Figure (dB)	PA OBO (dB)	Bit Rate (Mb/s)	Implementation Loss (dB)
L5 CMF	20	-2	7	7	5.0	0
L5 CMF+	20	-2	7	7	5.0	0
H5.5 (2,5)	20	-2	7	3	5.5	0
H5.5 (2,10)	20	-2	7	3	5.5	0
H5.5 (2,20)	20	-2	7	3	5.5	0
L10 CMF+	20	-2	7	7	10	0
H11 (2,5)	20	-2	7	3	11	0
H11 (2,10)	20	-2	7	3	11	0
H11 (2,20)	20	-2	7	3	11	0
M10	20	-2	7	1	10	0

Table 2-2 Link Budget Parameters

It should also be noted that the antenna diversity is not included in the link calculations since the trade matrix data was presented without diversity. Range was determined by adjusting the range to force the link margin to be slightly positive (0 to 0.5 dB) at the required Eb/No.

20% PER	5 Mb/s					10 Mb/s				
Delay Spread	5.5 Mb/s Harris (2,5)	5.5 Mb/s Harris (2,10)	5.5 Mb/s Harris (2,20)	5 Mb/s Lucent (CMF)	5 Mb/s Lucent(CMF +TSE+MS)	11 Mb/s Harris (2,5)	11 Mb/s Harris (2,10)	11 Mb/s Harris (2,20)	10 Mb/s Lucent(CMF+TSE+MS)	10 Mb/s Micrilor
0	7.7	7.7	7.7	6.3	5.5	7.7	7.7	7.7	6.5	6.6
25										
50										
75										
100						21.9	19.1	19.1		27
125	23.5								14	
150							21.7	20.4		26.5
175							25			
200							31.3	21.4		
225		25								
250							31.3	22.9		
275				19						
300										
325								27.5		
350					16.5					
375			27.5							
400										
425										
450										27.7

Table 2-3 Eb/No vs Delay Spread for Proposed Waveforms

3. Results / Conclusions

The results of the comparison are shown in Figure 0-1. From the figure it can be seen that all the waveforms give between 40 and 60 meters of range in thermal noise. As the multipath spread is increased all three waveforms degrade to between 18 and 30 meters in range. In all cases the 5 Mb/s rates provide more robust performance than the 10 Mb/s rates. The Harris equalized QMBOK approaches the performance of the Micrilor RAKE processing at large spreads as the size of the equalizer is increased. The Lucent 10 Mb/s mode has slightly higher performance (1-2 meters) than the Harris (2,10) and Harris (2,20) equalized QMBOK at around 100 ns delay spread. Performance of the Lucent approach at 10 Mb/s cannot be compared to either the Micrilor or Harris proposals beyond 100 ns since no data is available for it beyond its Trms of 130 ns.

The Micrilor proposal allowed evaluation at delay spreads at values other than that for Trms. In order to provide a more complete comparison, data for the Harris proposal was generated for various delay spreads between 50 and 300 ns with equalizers up to (2,40). This comparison is shown in Figure 0-2. It is postulated that if more data were available for the Lucent approaches they may also show performance similar to the Harris and Micrilor approaches at intermediate delay spreads. Both figures show Lucent performance in thermal noise and at Trms. The line drawn between the thermal point and Trms point gives a false impression of performance at intermediate delay spreads.

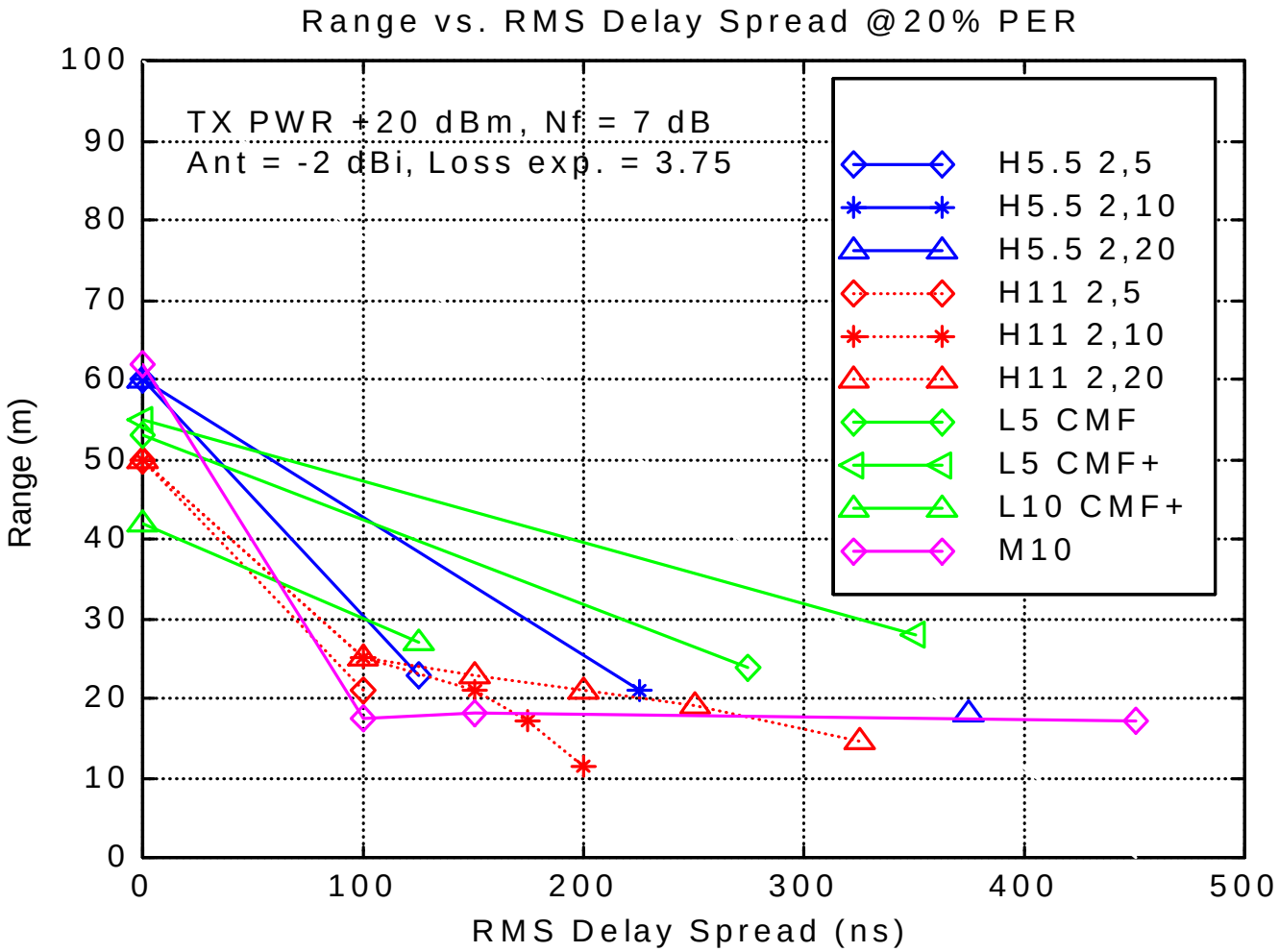

Figure 0-1 Waveform Comparison Results

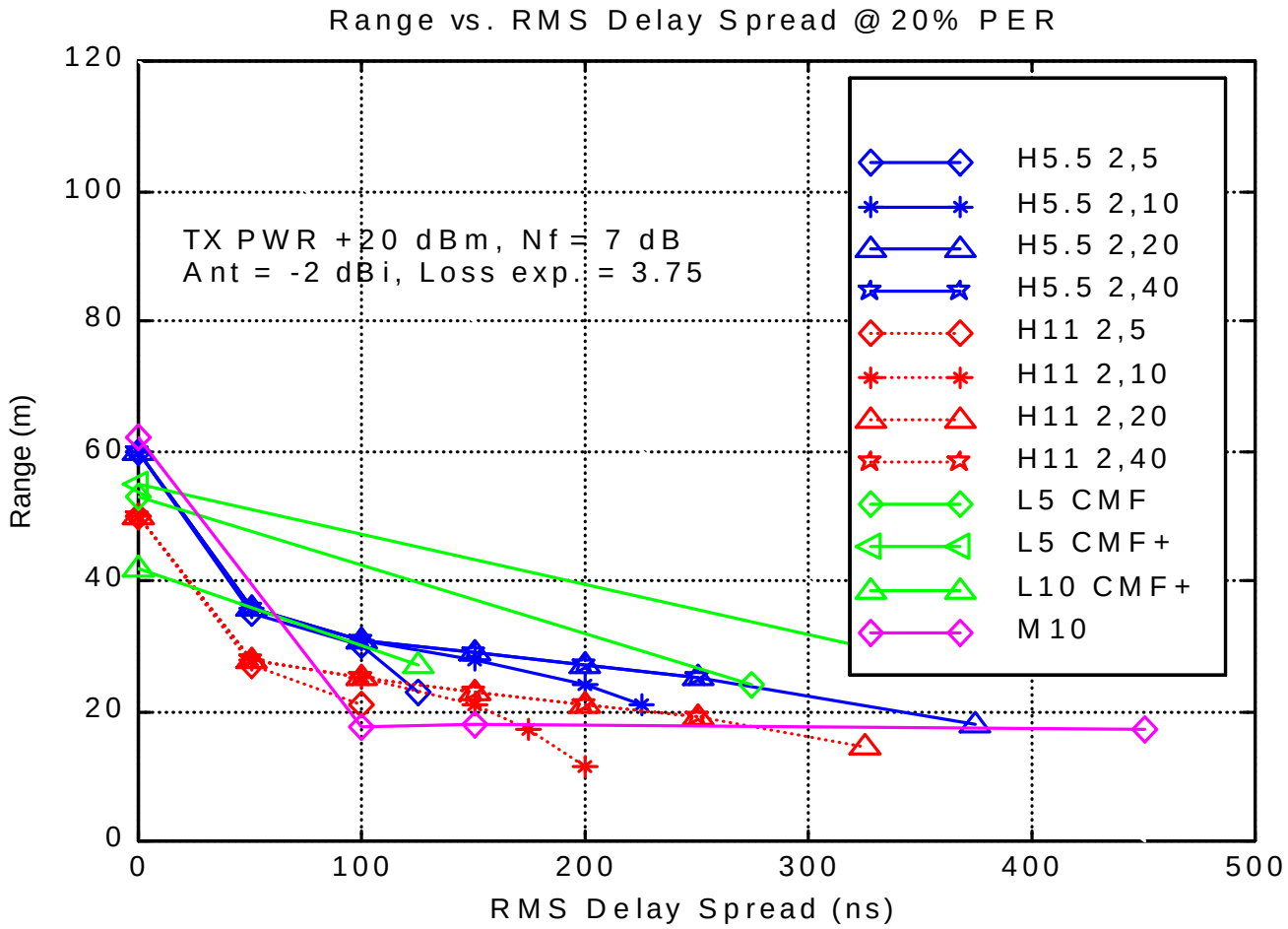

Figure 0-2 Comparison Results w/ Additional points for Harris Proposal