

**IEEE P802.11
Wireless LANs**

Impact of delay spread robustness on coverage range

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Abstract

The proposals of Harris, Lucent, Micrilor and Raytheon for the high data rate 2.4 GHz PHY have been compared with respect to delay spread robustness and coverage range. Delay spread depends on the type of building and (indoor) environment. More delay spread gives a reduction of the impact of fading on the receive level. However, at more delay spread the required SNR for a reliable link becomes larger. This influence on the required SNR effects the coverage range. The different proposals are compared in relation to the required SNR at delay spread values as occur in Office, Retail and Factory environments, and how these SNR values influences the coverage range performance.

1. Fading margin

Fig. 1 illustrates frequency selective fading. The wider the observed bandwidth or the larger the delay spread, the smaller the impact of fading on the received signal strength. The fading margin depends on the normalised delay spread ($\tau * BW$).

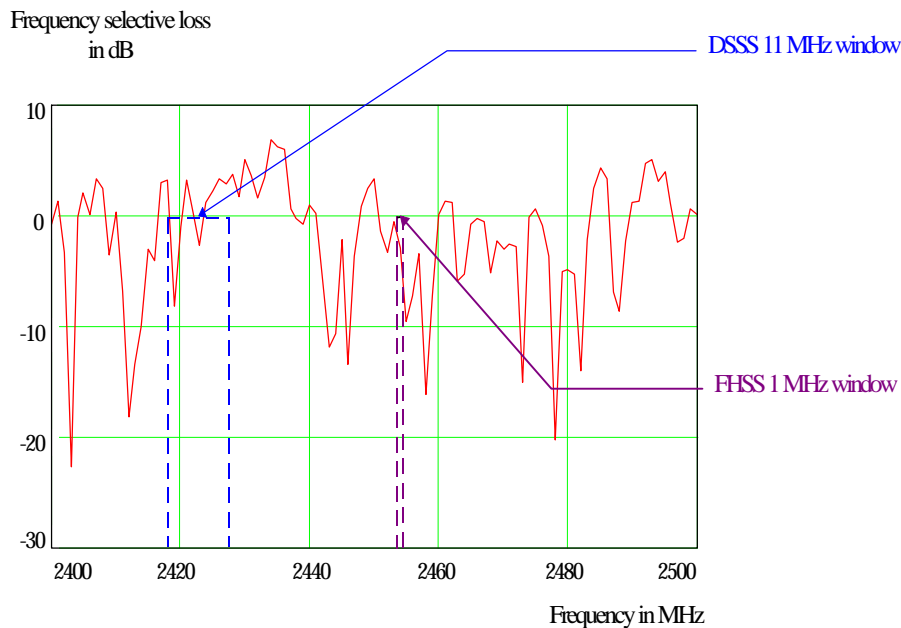


Fig. 1. Frequency selective fading at a delay spread of 100 nsec.

The adopted channel model (Doc. 97/157r1, p.6, Nov. '97) includes variation of the actual receive level. This variation is larger at low delay spread (flat fading) and smaller at large delay spread.

For system planning and installation of access points which cover a certain target range, we have to be aware of the sufficiently strong receive levels with respect to the margins on top of the receiver sensitivity. Such margins relate not only to fading but also to the degradation in the required SNR caused by delay spread.

2. Minimum target receive levels

Fig. 2 illustrates the minimum target receive levels for reliable operation at a range of delay spread values. Without delay spread (0 nsec) the fading could give significant lower actual receive levels than the target receive for a certain distance. The curves for theoretical systems operating at 11, 10 and 8 Mbit/s show a drop at more delay spread due to the lower impact of fading. These 11, 10 and 8 Mbit/s systems with required E_b/N_0 values around 7 dB give at a receiver noise figure of 7 dB receiver sensitivities around -90 dBm. The curves for these theoretical curves start 10 dB higher for the considered case (2 antennas and outage of 1%) and go down to asymptotes near -90 dBm. 11 Mbit/s (8 Mbit/s) requires a little higher (lower) receive level.

Reference points with E_b/N_0 degradation for a close-to-maximum tolerable delay spread have been presented. These reference points and their maximum tolerable delay spread are depicted as small coloured boxes in Fig. 2. In fact we can draw curves from the points around -80 dBm at delay spread 0 nsec to the boxes representing the reference points in question.

Table 1. E_b/N_0 figures without and with delay spread.

Name			E_b/N_0 @ 0 nsec (1000 byte packets)	E_b/N_0 @ tolerable delay spread (1000 byte packets)
Harris / Raytheon	QMBOK	11 Mbit/s	7 dB	23 dB @ 110 nsec
Lucent	BCPM	10 Mbit/s	6.5 dB	14 dB @ 130 nsec
		8 Mbit/s	7 dB	14.5 dB @ 235 nsec
		5 Mbit/s	6 dB	16.5 dB @ 355 nsec
Micrilor	16-ary DBOK	10 Mbit/s	7 dB	20 dB @ 160 nsec

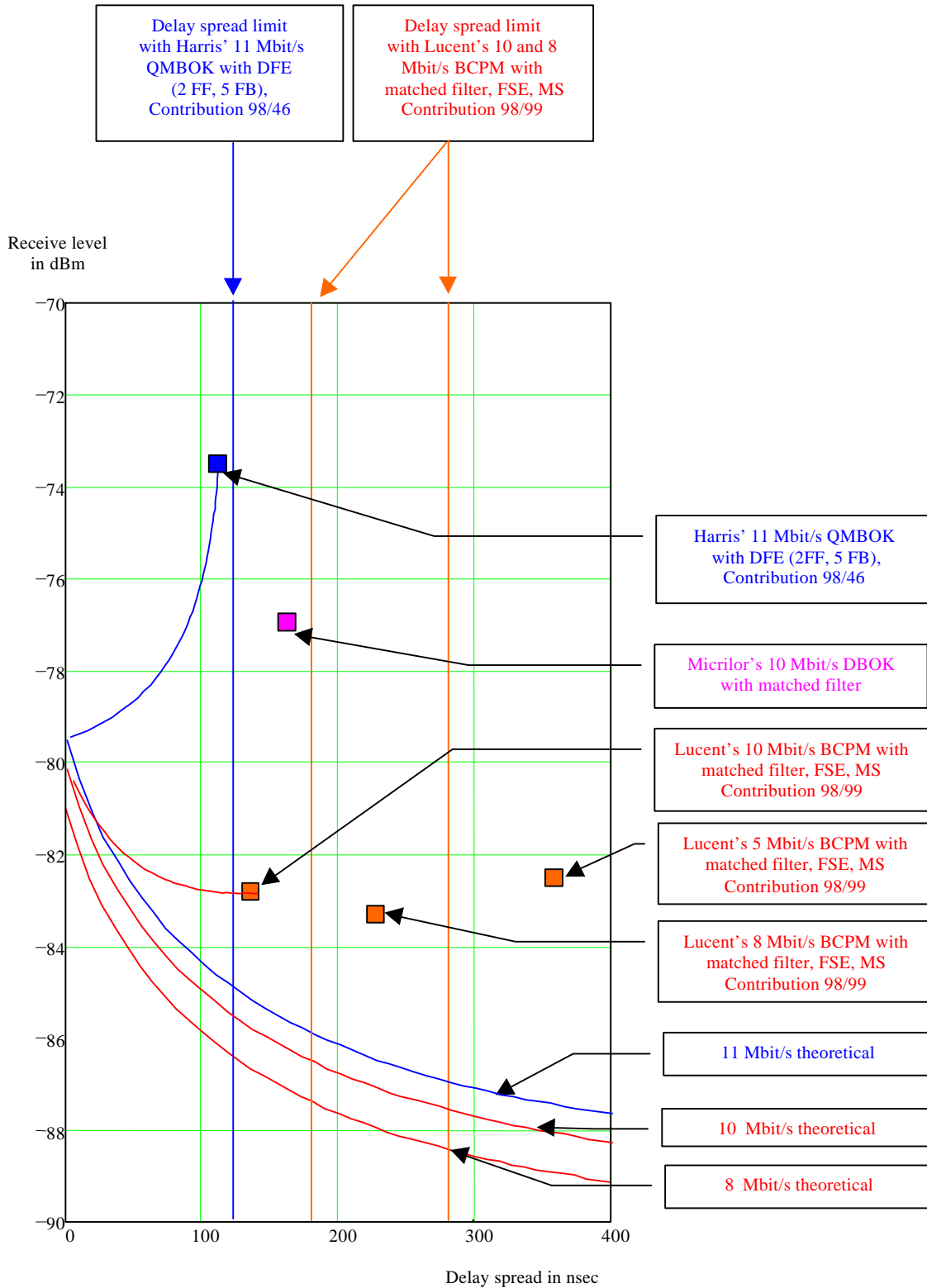


Fig. 2. Required receive level vs. delay spread with Harris (11 Mbit/s), Lucent (10, 8 and 5 Mbit/s) and Micrilor (10 Mbit/s).

3. Target receive levels and delay spread for different environments

Fig. 3 illustrates the required receive levels for reliable operation in three type of environments: Office, Retail/Warehouse and Factory. Thick lines represent for each of these environments the combination of the lowest target receive level and a range of expected delay spread values. The upper thick line stands for Office, the middle thick line reflects Retail/Warehouse, the lower thick line is for Factory. The three coloured boxes reflect again the reference points like in previous figure.

The Harris 11 Mbit/s scheme meets only the requirements for Office.

The Lucent 10 Mbit/s scheme meets the requirements for Office and partially those for Retail. To cover fully the Retail delay spread range the fallback to 8 Mbit/s has to be used. To cover Factory the 5 Mbit/s is needed and we find less range than the target maximum.

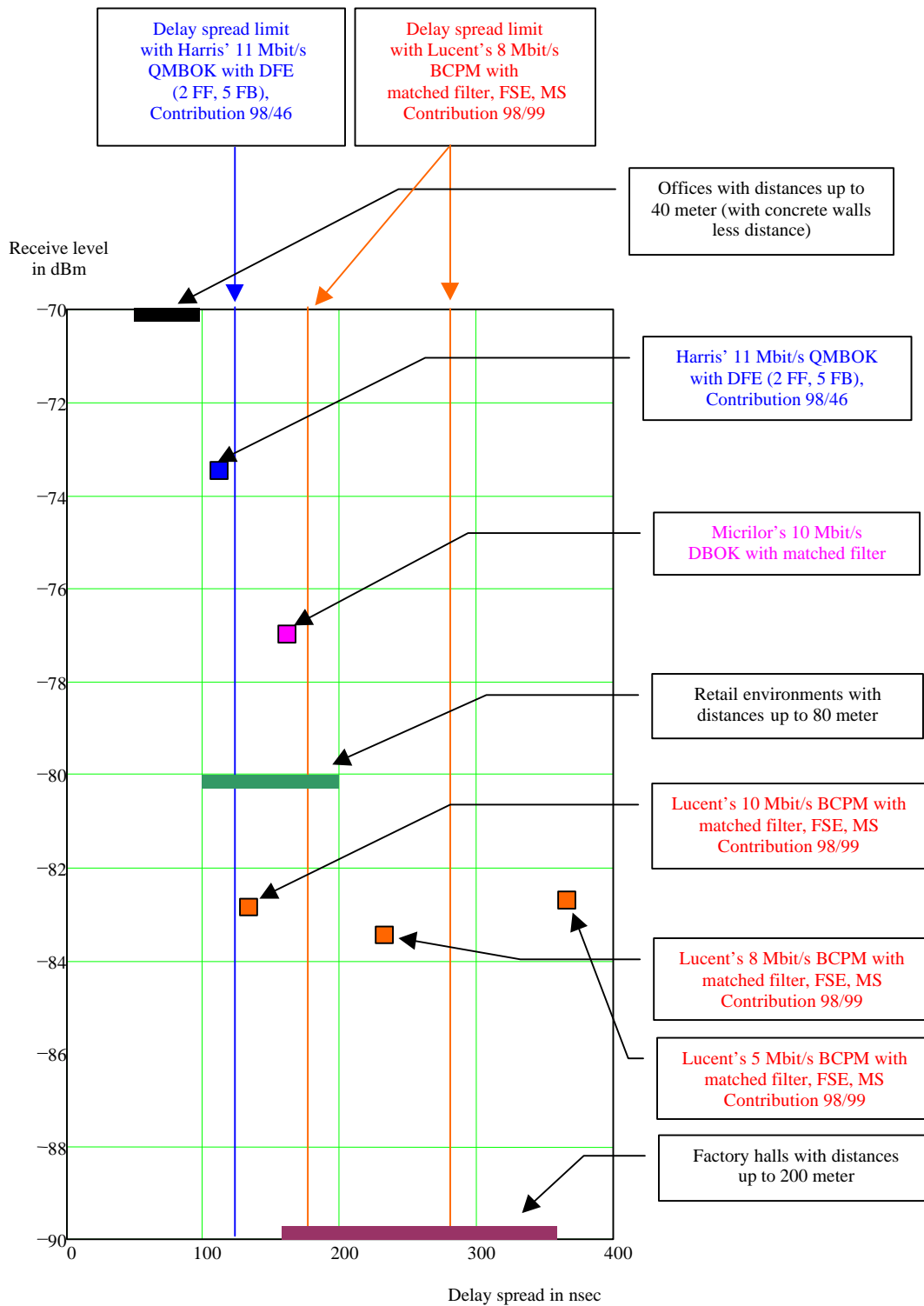


Fig. 3. Required receive levels and delay spread robustness for Office, Retail and Factory environments.

4. Coverage range for different environments

Fig. 4 illustrates the coverage range that can be met with a transmit power of 50 mW for different indoor environments. The lowest receive levels that are found for the proposed schemes in case of no delay spread, are pointed along the Y-axis around -80 dBm.

The upper (right) line gives the free space propagation path loss.

The lower multi-breakpoint line (curve) gives the path loss for Office. Since Office stands for delay spread up to 100 nsec, there are depicted ovals related to the tolerable receive ranges for the different schemes in relation to their delay spread robustness.

The middle multi-breakpoint line (curve) gives the path loss for Factory. The wider oval which hits this middle-most line, reflects the tolerable receive levels at delay spread as found for Factory environments.

In this way the maximum range for reliable operation can be found. The tolerable delay spread is very relevant in terms of the type buildings that are covered.

The Harris 11 Mbit/s scheme gives the target maximum range only for Office.

The Lucent 10 Mbit/s scheme gives the range shown for Office. To cover Retail fully the fallback to 8 Mbit/s has to be used. To cover Factory the 5 Mbit/s is needed, however with less range than the target maximum.

5. Conclusion

The Lucent scheme is more robust against delay spread and doesn't shrink its coverage range as quickly as the Harris (Raytheon) scheme at delay spread values typical for Office. Furthermore, the Lucent scheme allows operation in Retail/Warehouse and Factory environments.

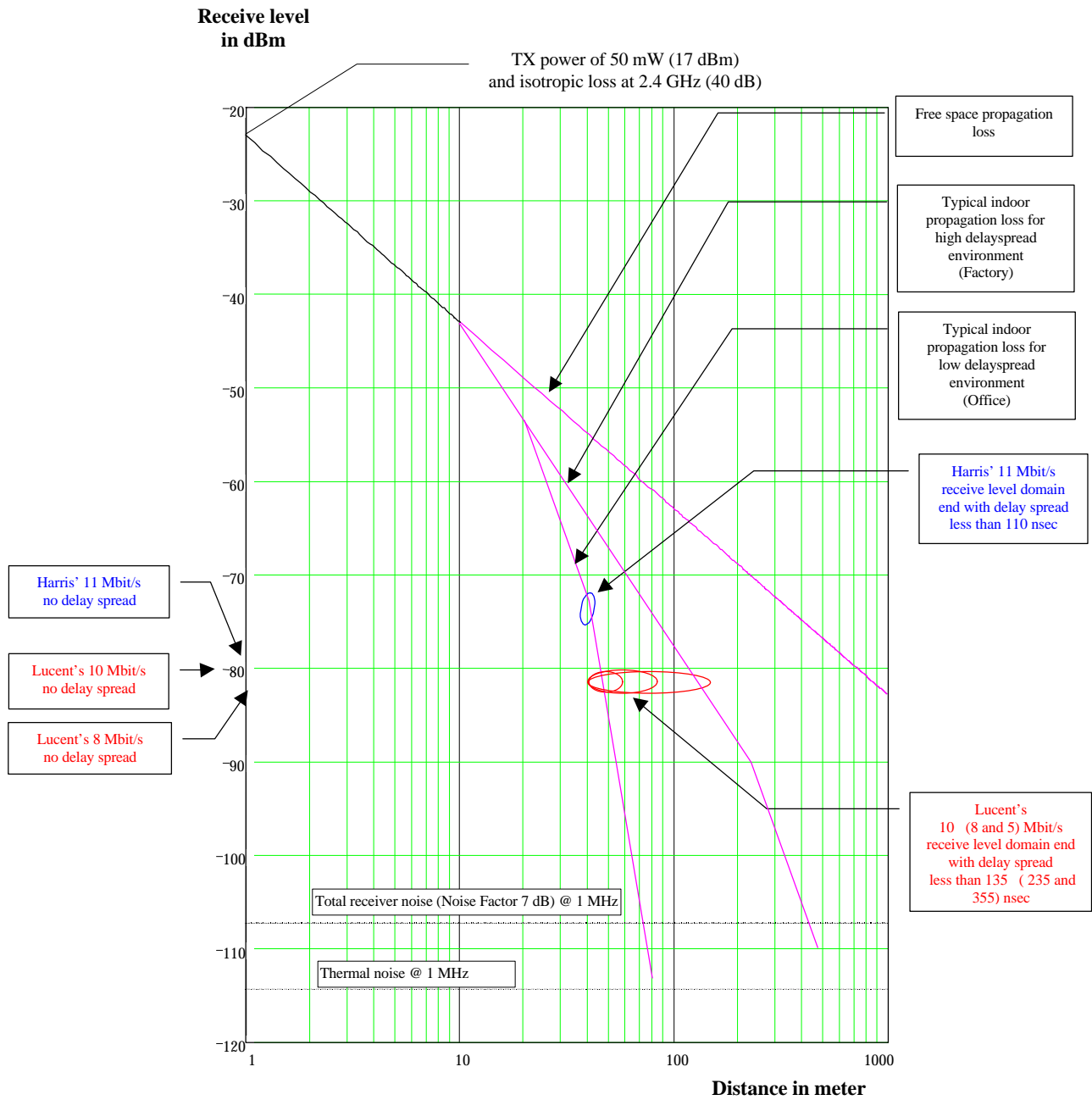


Fig. 4. Required receive levels to meet range for different environments.