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IEEE 802.4L Radio LAN
Submission on the Clarification of the Propagation Parameters in the Running Objectives and Directions Document

by
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The intent of this document is to clarify some of the propagation material in section 3.14 of the 802.4L Running Objectives and Directions Document as requested at the March meeting. It is proposed that the table be restructured as below. The table was checked for accuracy and a further description of the data contained in it is provided. It is left to the discretion of the group whether this level of detail needs to be included in the table.

No column was added on **coherence time** because of a lack of information on actual values for the parameter. However, Rappaport has some data on a related parameter in IEEE 802.4L/89-14a, *Radio Channel Modeling in Manufacturing Environments (Parts II and III)*. The Local Spatial Correlation (LSC) is defined and investigated in section 3.3 of this paper. LSC is a measure of how the channel varies with the position of a DTE and is thus a measure of channel variability with time for moving vehicles.

Local Spatial Correlation (LSC) is defined as follows:

Let,

$A(\tau,x) =$ The signal attenuation of the impulse response amplitude in dB at excess time τ and position x.

$M_A(\tau,x) =$ The local spatial average of the signal attenuation at excess time τ in the vicinity of location x.

Rappaport reports that $A(\tau,x)$ was found to be approximately normally distributed with a mean of $M_A(\tau,x)$. The local spatial correlation (LSC) is,

$$LSC(\tau,\Delta x) = \frac{E[(A(\tau,x)-M_A(\tau,x))(A(\tau,x+\Delta x)-M_A(\tau,x))]}{E[(A(\tau,x)-M_A(\tau,x))^2]}$$

Much the same as for the coherence time and the spaced-time correlation function, coherence distance could be defined as the value of Δx at which LSC becomes = 0. The local spatial correlation is about 0.2 at $\lambda/4$ and effectively 0 at $\lambda/2$ at nearly all values of excess delay. Thus coherence distance is approximately $\lambda/2$ in the Rappaport measurements.

The section 3.14 proposal and suggestions follow.

3.14 Propagation

environment	20 meter attenuation relative to 1 meter (dB)	slope (dB/octave)	standard deviation (dB)	RMS delay spread (within 20 dB from max peak) (ns)	notes
open retail	29-35	10-13.8	2.1-5.3	10-150	1
obstructed retail	40	19.4	4.5	not measured	2
factory	25-32	5.7-7.3	4.8-10.2	30 min 160 (95%) 280 max	3
office	39 1 location	11.7 1 location	2.2 1 location	10-50	4

Note 1: The open retail environment consists of a typical department store or supermarket with no more than 1 floor-to-ceiling wall in any path. Some otherwise shaded paths are included. These include paths shaded by elevator shafts and by concrete columns as well as merchandise and displays in the line-of-sight paths. The size varies from 21 meter maximum linear dimension to 110 meters maximum linear dimension.

The lowest delay spreads were measured in a small supermarket. These delay spreads were measured indirectly using the coherence bandwidth method. The variation of 4 measurements was 8 to 20 ns (coherence bandwidth of 8 to 20 MHz). The larger delay spreads were measured using the direct impulse response power delay profile. Values in large department stores are 50 to 150 ns.

The attenuation statistics (first 3 columns) were taken with CW measurements and were recorded separately for each location. The first 2 column parameters were computed by finding the set of values which minimized the standard deviation (third column). The standard deviation is that of the deviation from a regression line of 0 dB at 1 meter and 6 dB/octave (straight line against log distance) from 1 meter to the point where the low slope line intersects the higher slope line. An iterative procedure was used which varied the slope and 20 meter attenuation of the higher slope segment for minimum RMS deviation.

Note 2: The obstructed retail location was a department store with multiple floor-to-ceiling walls. Wall attenuation was measured at approximately 6 dB/wall. The maximum linear dimension of this store was 100 meters. There were approximately 10 walls in the longest paths.

Note 3: The factory information is from the report *Characterization of UHF Factory Multipath Channels* by Theodore S. Rapport and Claire D. McGillem, School of Engineering, Purdue University, West Lafayette, Indiana 47907, TR-ERC-88-12.

5 Light to heavy manufacturing locations were measured.

The attenuation statistics (first 3 columns) differ from the retail and office statistics in the manner in which the large scale loss curve fit was computed. The 10λ distance is the reference. The curve (regression line) was forced to 0 dB at the reference point and there is only one curve segment. The slope (second column) of the regression line is the value which minimizes the standard deviation (third column). The principal difference is that the regression line for the retail and office statistics was not forced to a particular point, but was allowed to vary in the vertical dimension to further minimize the standard deviation. Thus, the standard deviation of the factory measurements can be expected to be higher than that which would be determined by the retail and office environment method and the slope can be expected to be different. Rappaport reported that the techniques differ by no more than 0.2 dB in standard deviation and 1.5 dB/octave in slope.

Rappaport also computed attenuation values from the 50 wideband measurements made over the 5 sites. The attenuation values were computed from the impulse response power-delay profiles. The result for all sites was:

20 meter attenuation relative to 1 meter (dB)	slope (dB/octave)	standard deviation (dB)
26	6.5	4.9

The delay spreads were from the 50 wideband measurements. They were further broken down into those for obstructed paths (OBS) and line-of-sight (LOS) paths:

	Min.	50 Pctl.	95 Pctl.	Max.
OBS	30 ns	110 ns	140 ns	155 ns
LOS	30 ns	90 ns	150 ns	280 ns

The second largest RMS delay spread was 155 ns.

Note 4: The office environment information is from measurements of an engineering office location in The Netherlands and from the article *A Statistical Model for Indoor Multipath Propagation* by Adel A. M. Saleh and Renaldo A. Valenzuela, IEEE Journal on Selected Areas in Communications, Vol. SAC-5, No. 2, Feb., 1987.

The attenuation measurements are from the office location. *(Note: I do not have a copy of the article. Further attenuation information is probably included. Perhaps this can be added later)*

The maximum ofice delay spread (50 ns) is the maximum reported by Saleh and Valenzuela. In addition, the coherence bandwidth was measured for two paths in the office location. Coherence bandwidths were 8 and 16 MHz, corresponding approximately to RMS delay spreads of 20 and 10 ns.