IEEE P802.15
Wireless Personal Area Networks

Project	IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)
Title	**UWB Model below 1 GHz - Stochastic Extension**
Date Submitted	[29 October, 2004]
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Re:	This is an extension of the UWB model proposed in document 15-04-0505-02
Abstract	[This paper addresses the proposed extension of the UWB LOS channel model between 100 MHz and 1 GHz as described by Kai Siwiak in document number 15-04/505r2. This is mainly a summary of the issues discussed during the phone conference on Oct. 28, 2004.]
Purpose	[Description of what the author wants P802.15 to do with the information in the document.]
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UWB Model Below 1 GHz
Stochastic Extension

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October 29, 2004

Introduction

This paper adresses the proposed extension of the UWB LOS channel model between 100 MHz and 1 GHz as described by Kai Siwiak in document number 15-04/505r2. This is mainly a summary of the issues discussed during the phone conference on Oct. 28, 2004.

The current LOS model is a purely deterministic one, based on geometrical wave propagation inside a rectangular room. The main concerns raised during the telemeeting where related to the purely deterministic modeling approach:

- The number of echos is quite small and does not correspond to measurements [1]. This might lead to an unfair advantage of certain receiver types in the lower frequency band (100MHz – 1 GHz) compared to the band from 3 GHz to 10 GHz.
- The only amplitude variation of the echos is due changes in propagation path length if transmitter and/or receiver are displaced. However, small scale fading is the dominant source of channel uncertainty in mobile communications, as observed in virtually all measurements of indoor channels [2]. Although it would be theoretically possible to model the fading effect deterministically by solving the complete set of Maxwell's equations for the porpagation scenario under consideration, the complexity is prohibitively high. Hence a statistical description is the only possibility to obtain a realistic model. Communication systems operating over a large bandwidth with little available power are susceptibel to channel uncertainty, and channel estimation gets increasingly more difficult the more the available power is distributed over an increasing number of channel taps [3, 4], necessitating a model that takes into account this power dispersion.

Proposed Extension

The main idea is to use the proposed deterministic model as a starting point for a Saleh-Valenzuela [5] type statistical model, where the deterministic arrivals computed from the room geometry specify the cluster arrival times and average cluster power. Each cluster in turn is composed of several more taps with an exponentially decaying power delay profile, where the tap amplitudes are modeled according to some probability distribution. For best agreement with the available literature and for compatibility with the high band model from 3 GHz to 10 GHz, it seems reasonable to model the amplitudes as Nakagami distributed.

Since the bandwidth is fixed, it makes sense to use a discrete time model, which is most amenable for simulation purposes. Hence the model would have the following structure:

$$h[n] = \sum_{k=1}^{K} a_k \sum_{l=0}^{L-1} \alpha_{kl} \delta[n - \tau_k - l]. \tag{1}$$

The symbols have the following meaning

- There are K clusters, each cluster begin corresponds to one of the principal echos is the deterministic model.
- a_k is the attenuation of the kth cluster, which can be computed from the path lengths in equations (1) – (11) and (13) and the respective wall attenuation factors in document 502r2, as shown in equation (23). This equation is indeed equivalent to the outer summation above.
- The clusters start at delays indicated by τ_k. These delays can also be calculated from the room geometry, by dividing the excess distances in equation (13) by the speed of light.
- Every individual tap has an amplitude α_{kl} that is a random variable. The distribution of each random variable is Nakagami. The power Ω follows a normalized exponential power delay profile $\propto e^{-l/\gamma}$, where the decay constant γ and the number of taps per cluster L still needs to be specified. The Nakagami m factor also needs to be specified. One possibility would be to choose a randomly varying m factor according to the model by Cassioli, Win and Molisch [1].
- One last issue is the question if the model should be a baseband model or a baseband equivalent model. For consistency and because the frequency band is not centered at dc, I would opt for a baseband equivalent model. In this case, the tap amplitudes α_{kl} for $l = 0$, i.e., the cluster start taps, would have an extra phase factor $e^{-j2\pi\tau_k}$, whereas the other tap amplitudes need to be multiplied by a phase factor with uniform distribution. A somewhat tricky issue in baseband equivalent formulations is the power normalization (the infamous factor of 2). In the end, the absolute power does not matter as long as the power of the additive noise is normalized in the same way [6].

References

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