GEOMETRIC OPTICS INDOOR CHANNEL MODEL

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OVERVIEW

A waveform channel model can be used in software link simulation, hardware testing, the design of conformance testing equipment such as anechoic chambers, and the contruction of discrete channel models used in network performance prediction. The physical layer working group of the IEEE 802.11 has yet to adopt a waveform channel model. Impulse response measurements performed by the Institute for Telecommunication Sciences (ITS) are currently used as the "standard channel" for simulations. Simulations of wireless local area networks (WLANS) operating in an open office building using omnidirectional antennas can be performed with these measurements.

WLANS are likely to use switched or combined outputs from mulitple directional antennas and to operate in many different types of buildings. The geometric optics (GO) channel model offers a more realistic approach than measurements for providing channel models of many combinations of buildings and antennas. This submission summarizes channel modeling efforts within the physical layer working group, recommends adoption of a GO channel model, and lists the requirements for the standard GO channel model.

IEEE P802.11 CHANNEL MODELING HISTORY

Geometric optics and statistical modeling approaches were summarized in "Modeling the Wideband Indoor Channel Complex Impulse Response" (Achatz, IEEE P802.11 92/133) to fascillitate working group discussion. The submission concluded that one of the major advantages of the GO model is the ability to quickly change antenna patterns and antenna position. The inadequacies of statistical channel models that used averaged channel statistics were pointed out in "Toward a Proper Model of the Portable Indoor Channel Model" (McKown, IEEE P802.11 92/70). It was argued that modern portable wireless modems will have intelligent RF front ends that will estimate the channel state and use this information to optimize performance. The GO channel model preserves the channel's temporal and spacial correlations that intelligent RF front ends are likely to exploit. A channel model that preserved motion effects was proposed in "A Simple Indoor Microwave Channel Model With Realistic Motion Effects" (McKown, Van Der Jagt, IEEE P802.11 93/31). Although this model was not based entirely on GO, it used GO principles to preserve the spatial correlations of the multipath components. It also incorporated user defined antenna patterns.

At this time the physical layer working group has not selected a channel model but has voted to use the ITS measured impulse responses as a standard channel. Other members of the IEEE 802.11 committee were asked to share impulse response measurements so that a wide range of buildings and antennas are included. The ITS measurements were described in "Wideband Propagation Measurements for Wireless Indoor Communication" (Papazian, Achatz, IEEE P802.11 92/83) and the method for distributing the data magnetically was documented in "Indoor Wideband Propagation Data" (Achatz, IEEE P802.11 93/41). The data constists of thousands of impulse response measurements taken with high spatial resolution over a 25 meter by 25 meter soft partitioned office environment.

The disadvantage of using channel measurements is that simulations performed with the measurements are valid only for that type of building and measurement antenna. A measurement library consisting of many building and antenna combinations can be built up however this is costly. Statistical models that maintain spacial correlations also require an exhaustive measurement campaign. The GO model is the best choice since it can generate impulse responses of different buildings and antennas easily while still maintaining the spatial correlation properties of the multipath components.

REQUIREMENTS FOR GEOMETRIC OPTICS INDOOR CHANNEL MODEL

The requirements of the GO indoor channel model are:

1) The transmitter and receiver are assumed to be located in a cuboidal room i.e. four walls, a ceiling and floor. The dimensions of the cuboid are determined by the class of building (small office, medium office, large office etc.). The cuboid has been selected for its ubiquity as a room shape and the simplicity in modeling with GO.

2) No objects are in the cuboid. The most powerful multipath components in the indoor channel are the result of specular reflections off interior wall, floor, and ceiling surfaces. Reflections off objects are generally diffuse and attenuated more with distance.

3) The electromagnetic properities of the walls, floor, and ceiling are to be specified in terms of a complex reflection coefficient with vertical and horizontal components. The phase and amplitude of the reflection coefficient is a function of the angle of incidence of the ray. Each wall, floor, or ceiling material would have a different reflection coefficient that would be determined by the material and frequency. Each time a ray is reflected off a surface, it is attenuated by the complex reflection coefficient.

4) Rays are attenuated by a distance attenuation exponent of 2.

5) The transmitter and receiver antenna patterns are described three dimensionally in both E and H planes. Rays leaving the transmitter or entering the receiver are attenuated by the antenna pattern.

6) Paths may have up to five reflections.

7) Impulse responses may be generated over any linear, circular, or random path through the cuboid with high spatial resolution. This would allow realistic simulation of impulse response behavior as the modem is moved. The other modem is assumed to be stationary although its location in the cuboid is arbitrary.

8) Rays may be individually switched on and off at varying rates to simulate the effect of rotating machinery.

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