

Physics-based Communications Models for Random Complex Environments

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Extended Abstract

Extensive research has been reported on MIMO systems for complex environments. For example, extensive work on communications through various propagation paths, including keyhole channels, has been reported by Loyka and others.

It is also noted that communications through random complex media such as atmospheric turbulence, particulate matter, and rough surfaces, with diffraction and diffusion, may need to be included and combined in communications studies. These studies include coherent and incoherent waves, and correlations represented by an MCF (mutual coherence function). These may be called "physics-based" models. While many communications studies make use of the channel matrix of transmitter and receiver signal vectors, physics-based studies include the wave characteristics and the mutual coherence function, which need to be obtained from the characteristics of the random media itself such as statistical descriptions of turbulence, surface characteristics, particle density, and the boundary conditions. The transfer matrix is then obtained by including the medium characteristics and the mutual coherence function.

It may be noted that studies including keyhole effects may also be considered partially "physics-based", since they include the effect of holes consisting of waveguides of various sizes that are within the propagation path. On the other hand, the physics-based modeling approach described in this paper includes the effects of actual physical random media, in the form of statistical characteristics such as turbulence spectrum, particle densities, surface roughness with rms heights, and correlation length. This approach may be classified as a more general physics-based communications model.

A physics-based model for general random and complex environments that combines communications models with channel matrix, signal vectors, SNR, and eigenvalues, and models with propagation and scattering in random media, still requires further study. We have done a simpler study of channel capacity of a MIMO system for a 500m link at 60 GHz through rain, which includes all the scattering characteristics of rain particles, the rain rate, the optical depth, the stochastic Green's function, and the resulting eigenvalues and channel capacity. Further study is needed to clarify the relations between channel studies that include a keyhole channel, and generalized physics-based models.

This paper describes the need to further study the characteristics of a physics-based communications model for random complex media environments, the benefits and challenges of such a modeling approach, and outstanding research questions that still need to be addressed.