A New MIMO Channel Model Including Diversity, Orientation and Depolarization Effects

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A signal transmitted into the wireless channel suffers a large number of distortions that range from the well known amplitude attenuation and phase change to the relatively less known channel depolarization effects (slight changes in the polarization of the transmitted signal due to scattering). In multiple-input multiple-output (MIMO) systems, the use of multiple antenna elements introduces the factors of spatial, polarization and pattern diversities. Further, mutual coupling effects come into play between antenna elements, particularly when they are placed close together. The orientation of the transmit and receive arrays, and imperfect antenna cross-polar isolation (XPI) are also important effects to take into account. While a large number of channel models have been developed to characterize the MIMO channel model, none of them (to the best of our knowledge) model *all* the above mentioned channel and antenna effects. We present a *comprehensive* analytical channel model that includes the channel and antenna effects mentioned above. The proposed channel model uses the ray-based clustered channel approach employed in the IEEE 802.11n model and 3GPP spatial channel model to combine all the diversity effects into array response vectors. Random orientation of the receive terminals is modeled using a rotation matrix.

Making the narrowband assumption, the net channel realization, $\mathbf{H}$ is represented as the sum of contributions from L clusters, i.e. if $\mathbf{H}_\ell$ is the channel representation for the ℓth cluster, then $\mathbf{H} = 1\sqrt{L}\sum_{\ell=1}^{L}\mathbf{H}_\ell$. The channel for the ℓth cluster, $\mathbf{H}_\ell$ is then evaluated using the ray-based approach as

$$\mathbf{H}_\ell = \frac{1}{N}\sum_{n=1}^{N}\alpha_n \mathbf{a}^r_{\text{net}}(\phi^r_{n,\ell})(\mathbf{a}^t_{\text{net}}(\phi^t_{n,\ell}))^\dagger$$

where n is the index for the number of rays, N within the ℓth cluster, α_n is a complex Gaussian random variable with zero mean and unit variance and $(.)^\dagger$ stands for the Hermitian transpose. Also, $\mathbf{a}^r_{\text{net}}(\phi^r_{n,\ell})$ is the *net* receive array response vector at an angle of arrival of $\phi^r_{n,\ell}$ and $\mathbf{a}^t_{\text{net}}(\phi^t_{n,\ell})$ is the *net* transmit array response vector at an angle of departure of $\phi^t_{n,\ell}$. The angles of arrival and departure are obtained using the truncated Laplacian distribution, on the lines of the IEEE 802.11n channel model. In the proposed analytical channel model, the *net* array response vectors include all the channel and antenna effects mentioned above, and are represented in the form

$\mathbf{a}_{\text{net}} =$	Spatial Diversity $\times$ Polarization Diversity $\times$ Pattern Diversity $\times$ Random Orientation (rotation matrix) $\times$ Channel Depolarization.

The performance of the proposed MIMO channel model is compared to that of analytical models like the Kronecker model to show that the proposed model provides a relatively more accurate representation of the wireless channel.