Optimal Rate and Power Allocation for Layered Transmission with Superposition Coding

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We consider the problem of transmitting an analog source over a quasi-static fading channel. This problem is motivated by the recent demand for multimedia content over wireless channels. The goal is to minimize the expected distortion of the received signal. Over slowly fading channels, the delay sensitivity of multimedia applications limits channel coding to a single fading realization. Due to the non-ergodicity of the channel, Shannon's separation theorem does not hold and a joint source-channel coding approach is more appropriate. When no channel state information is available at the transmitter, a multiple-antenna fading channel with either one receive or one transmit antenna can be modeled as a degraded broadcast channel where each channel realization corresponds to a user. The optimal transmission strategy for the degraded broadcast channel is superposition coding. Codewords of different rates and powers are superimposed and transmitted over the channel. At the receiver, the fading channel realization allows the layers up to a certain level to be decoded, while considering the undecodable layers as interference. The problem is to find the optimal rate and power allocations that minimize the expected distortion. In [1], the optimal distortion exponent for this system is derived that is defined as the slope of the expected distortion curve with respect to the channel signal to noise ratio (SNR) for asymptotically high SNRs. In our work, we propose an efficient numerical technique to explicitly solve the rate and power allocation problems at a finite SNR. Our proposed algorithm iteratively optimizes the rates for a given power allocation and vice versa, and is guaranteed to converge. Fig. 1(a) shows the results for a complex Gaussian source and one-transmit, one-receive antenna (1x1), and 4x1 systems with different number of layers (N). The bandwidth expansion ratio, b, is the number of channel symbols transmitted per source symbol. It is seen that *5* layers achieves almost all the gain associated with layering. Fig. 1(b) represents the gain of superposition coding with respect to time-sharing [2]. Fig. 1(c) shows that for very small N ($N=2$) and large b ($b=10$), unequal rate allocation provides gains up to *1.8dB*. For other scenarios, however, optimal power allocation with equal rate assignment is nearly optimal.

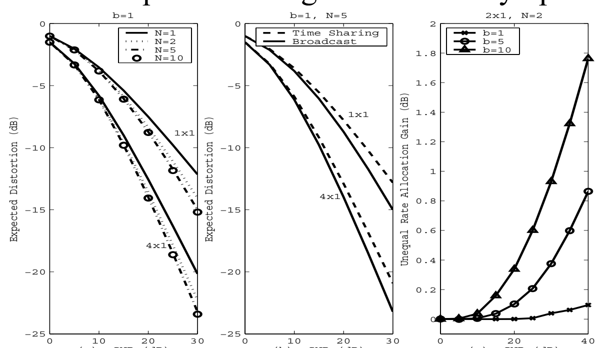

Fig.1 (a) Number of the layers (b) Comparison with time-sharing (c) Unequal rate allocation gain

References

[1] D. Gunduz, E. Erkip, "Distortion Exponent of MIMO Fading Channels", *IEEE ITW,* March 2006.
[2] F. Etemadi, H. Jafarkhani, "Optimal Layered Transmission over Quasi-Static Fading Channels", *IEEE ISIT*, July 2006.

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