Space-Time Autocoding: Arbitrarily Reliable Communication in a Single Fading Interval

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Abstract — **Prior treatments of space-time communications in Rayleigh flat fading generally assume that channel coding covers either one fading interval—in which case there is a nonzero "outage capacity"—or multiple fading intervals—in which case there is a nonzero Shannon capacity. However, we establish conditions under which channel codes span only one fading interval and yet are arbitrarily reliable. In short, space-time signals are their own channel codes. We call this phenomenon *space-time autocoding*, and the accompanying capacity the *space-time autocapacity*.**

Let an M-transmitter-antenna, N-receiver-antenna Rayleigh flat fading channel be characterized by an $M \times N$ matrix of independent propagation coefficients, distributed as zero-mean, unit-variance complex Gaussian random variables. This propagation matrix is unknown to the transmitter, remains constant during a T-symbol coherence interval, and there is a fixed total transmit power. Let the coherence interval and number of transmitter antennas be related as $T = \beta M$ for some β. A $T \times M$ matrix-valued signal, associated with $R \cdot T$ bits of information for some rate R is transmitted during the T-symbol coherence interval. Then there is a positive space-time autocapacity C_a such that for all $R < C_a$, the block probability of error goes to zero as the pair $(T, M) \to \infty$ such that $T/M = \beta$. The autocoding effect occurs whether or not the propagation matrix is known to the receiver, and $C_a = N \log(1 + \rho)$ in either case independently of β, where ρ is the expected SNR at each receiver antenna. Lower bounds on the cutoff rate derived from random Unitary Space-Time signals suggest that the autocoding effect manifests itself for relatively small values of T and M. For example within a single coherence interval of duration $T = 16$, for $M = 7$ transmitter antennas and $N = 4$ receiver antennas, and an 18 dB expected SNR, a total of 80 bits (corresponding to rate $R = 5$) can theoretically be transmitted with a block probability of error less than 10^{-9}, all without any training or knowledge of the propagation matrix.

A complete copy of this paper is available on the web at `http://mars.bell-labs.com`.

References

[1] B. Hochwald, T. Marzetta and B. Hassibi, "Space-time autocoding," submitted to *IEEE Trans. Info. Theory*. Also Bell Labs. tech. report, Nov. 1999.

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