Performance Evaluation for Multiple-Symbol Differential Detection with Multiple Interferers

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Abstract — **Multiple-symbol differential detection (MSDD) is applied to communication systems operating over a slow Rayleigh fading channel in the presence of multiple interferers. The channel of the desired signal is assumed to be unknown. An expression for the exact pairwise error probability is derived. The approximate upper bound of the bit error probability is obtained as well. Analytical and simulation results show that MSDD can achieve performance that is close to that of detector using optimum combining and differential encoding.**

Multiple-symbol differential detection (MSDD) was first proposed by Divsalar and Simon for uncoded multiple phase-shift keying (M-PSK) and the additive white Gaussian noise (AWGN) channel [1]. They developed a decision statistic assuming a channel with unknown, but fixed phase over multiple symbol intervals. They showed that for a long observation interval, the performance of noncoherent MSDD approached that of coherent detection (with differential encoding at the transmitter). The same authors extended the method to trellis coded M-PSK in [2]. Simon and Alouini applied MSDD to channels with reception diversity in [3].

In previous work [4], we developed MSDD for systems with reception diversity in the presence of white Gaussian noise and a *single* interferer. The signal constellation used was uncoded M-PSK. The channel information of the desired signal was assumed to be unknown but the covariance matrix of the interference plus noise was assumed to be known. Analytical expressions for the pairwise error probability (PEP) and an approximation upper bound of the bit error probability (BEP) were derived.

In this paper we extend MSDD to systems with multiple interferers. Although the approach used here is similar to that in [4], the mathematics leads to more complicated expressions. The expression we obtain for the exact PEP involves multiple-fold integration. When the number of interferers is less than that of reception branches, we can get an approximate closed-form expression for the PEP.

Based on the expressions for PEP, we obtain an expression for the approximate upper bound of BEP, which is a very good approximation to the BEP obtained by simulation when the number of reception branches is large. We show asymptotically the BEP of a system with N reception branches and L larger interferers is equal to the BEP of a system with $(N-L)$ reception branches but without interference.

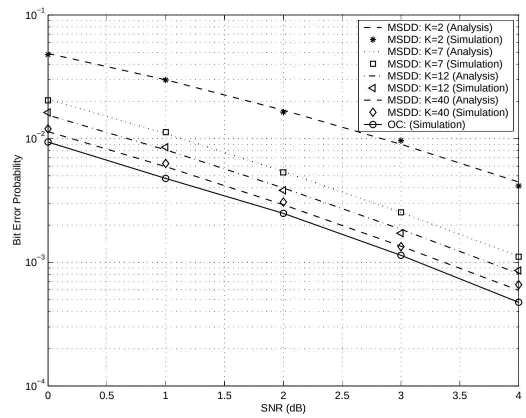

Fig. 1: BER versus SNR for MSDD and OC, 8 reception branches, 3 interferers, SIR $= -10$ dB, differential binary phase-shift keying (DPSK).

The main result of this paper is, when there are more than one interferer, the conclusions drawn in [4] is still valid, i.e., with the increasing number of received symbols in the observation interval, the performance of MSDD approaches that of optimum combining (OC) (with differential encoding).

The results of this paper are demonstrated by Fig. 1. It shows the BEP versus signal to noise ratio (SNR) for the case of 8 reception branches and 3 interferers. It is observed that the analytical results are very close to the simulation results. Fig. 1 also shows that as K (which is the number of symbols in the observation interval) increases, MSDD can achieve performance approaching that of the detector using OC with differential encoding. When $K = 40$, the difference between MSDD and OC (in terms of SNR) is less than 0.3 dB.

References

[1] D. Divsalar and M. K. Simon, “Multiple symbol differential detection of MPSK,” *IEEE Transactions on Communications*, pp. 300–308, March 1990.

[2] D. Divsalar and M. K. Simon, “The performance of trellis-coded MDPSK with multiple symbol detection,” *IEEE Transactions on Communications*, pp. 1391–1404, September 1990.

[3] M. K. Simon and M.-S. Alouini, “Multiple symbol differential detection with diversity reception,” *IEEE Transactions on Communications*, vol. 49, pp. 1312–1319, August 2001.

[4] D. Lao and A. Haimovich, “Multiple-symbol differential detection with interference suppression,” *Proceedings of the 2001 Conference on Information Sciences and Systems, Johns Hopkins University, Baltimore*, vol. 2, pp. 850–855, March 2001.

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