다중 릴레이 협력통신의 LLR 선택적 합성기술

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LLR selection combining in multiple relay cooperative communication

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Abstract

We propose a LLR (log-likelihood ratio) selection combining technique that reduces much of complexity. This technique chooses the most reliable branch based on the magnitude of the LLR of each branch. We show that the proposed selection combining achieves significant power gains over conventional selection combining and nearly matches the performance provided by MRC.

I. Introduction

Wireless transmission is severely degraded due to multipath fading effects. Diversity was devised to combat of rayleigh fading [3]. Cooperative communication was born to take advantage of spatial diversity. Selection combining is a good choice to reduce complexity at the receiver, [1] introduces an optimum selection combining technique that chooses the most reliable branch. The reliability is shown to be proportional to the magnitude of the log-likelihood ratio of the received symbol.

In this letter, we propose a multiple relay cooperative system that applies amplify and forward protocol and optimum selection combining at the destination and thus substantially reduces implementation complexity.

We show that the proposed technique achieves exactly the same performance provided by MRC for the one relay case and almost same with MRC for higher number of relays. The optimum selection provides significant power gain over conventional selection combining.

II. System Model

We consider a cooperative communication system that includes: 1 Source (S), M relays (R_m) and 1 destination (D) all of which communicate in wireless environment, M relays help the source by simply amplifying and forwarding the signals they receive from the Source. To prevent interference, orthogonal channels (time slots, frequency bands, or codes) are assigned to users. The channel estimation is assumed to be perfect at the receivers but not the transmitters. The channel is assumed to be slowly time-varying flat fading. The complex baseband equivalent models are used for simple exposition. The transmission process includes 2 phases. In the first phase, the source broadcasts a symbol x to the relays and the destination, the received signals are given by:

$$y_{SD} = h_{SD}\sqrt{E_0}x + n_{SD} \tag{1}$$

$$y_{Sm} = h_{Sm}\sqrt{E_0}x + n_{Sm} \tag{2}$$

In the second phase, the relays amplify the received signal and forward it to the destination on the assigned channels. The signals that the destination receives from the relays are:

$$y_{mD} = h_{mD}\alpha_m y_{Sm} + n_{mD} \quad (3)$$

where E_0 is the transmitted symbol energy of the sender, x is BPSK-modulated symbol which takes the value of 1 or -1 with equal priori probability. The effect of the slowly varying flat fading from node i to node j is captured by h_{ij} ($i = S, m$; $j = m, D$ and $m = 1, 2, \cdots, M$) which are assumed to be i.i.d zero-mean complex Gaussian r.v.'s with variance V_{ij}. The additive noises n_{ij} are AWGN with variances N_{ij}. α_m is an amplification factor at the relay m. The destination calculates the LLR values of individual link and chooses the largest to detect.

Ⅲ. Simulation Results

The non-cooperation direct transmission from the source to the destination is provide for comparison, and is assumed to have the energy per bit E_T. The power constrain requires that the total consumed power of cooperative communication doesn't exceed the power of direct transmission $\sum_{m=0}^{M} E_m \le E_T$, we therefore let the source and all the relays have the same power $E_m = E_T/(M+1)$ for simplicity. All the channel fading hij is assumed to be unit average energy, i.e., $V_{ij} = 1$. We consider equal unit variance noise on all paths $N_{ij} = N_0 = 1$. We compare the cases of MRC, optimum selection combining and conventional combining. Direct transmission is also provided to illustrate the diversity gain. System with one relay is plotted in Fig. 1 which confirms our argument that optimum selection combining is exactly the same with that provided by MRC. The reason is that there is only two links and therefore the metric of MRC always has the same sign with the optimum selection metric, i.e., the maximum log-likelihood ratio. The optimum selection provides a power gain of 1.5 dB over the conventional selection combining for almost the range of SNR. All three combining techniques achieve full diversity order 2.

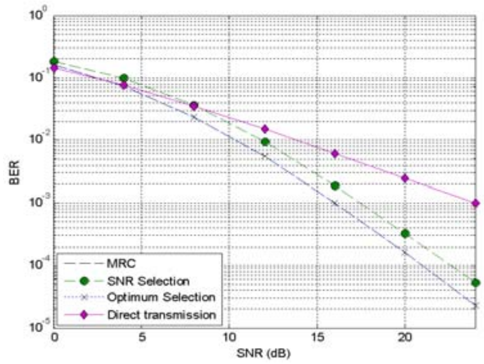

Fig 1. Bit error probability versus E_T/N_0 for one relay case

Ⅳ. Conclusion

In this letter we presented applications of optimum selection combining in cooperative communication systems. These applications reduce greatly complexity imposed by MRC while still achieving nearly the performance of MRC and obtaining large power gain over conventional combining. The rationale behind this is that selection is based on the probability of error and its relationship to the LLR. The link providing the largest LLR magnitude is chosen to make a final decision. We believe our proposal creates a good chance for multiple relay systems become realizable.

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