Lecture 12 - EE 359: Wireless Communications - Autumn 2015

Maximal Ratio Combining. Transmit Diversity.

Lecture Outline

- Maximal Ratio Combining (MRC)
- Performance of MRC with i.i.d. Rayleigh fading
- MGF Analysis of MRC
- Transmit Diversity

1. Maximal Ratio Combining (MRC)

- Branch weights optimized to maximize output SNR of combiner.
- Optimal weights are proportional to branch SNR.
- Resulting combiner SNR $\gamma_{\Sigma}$ is sum of branch SNRs.
- Distribution obtained by characteristic function analysis (can be hard).

2. Performance of MRC with i.i.d. Rayleigh fading

- For $M$ branch diversity with i.i.d. Rayleigh fading on each branch, $\gamma_{\Sigma}$ is chi-squared with $2M$ degrees of freedom.
- Can obtain $P_{out}$ and $P_s$ from this distribution.
- For BPSK, get 15 dB gain at $10^{-3}$ BER. Larger gains obtained at lower BERs.

3. MGF Approach to MRC Diversity Analysis.

- Distribution of $\gamma_{\Sigma}$ hard to obtain when fading is not Rayleigh or not identically distributed.
- Can use alternate $Q$ function representation to greatly simplify $P_s$ calculation.
- Using alternate representation and switching order of integration yields

\[
P_s = \frac{\alpha_M}{\pi} \int_0^{\pi/2} \prod_{i=1}^M \mathcal{M}_{\gamma_i} \left[ -\frac{5\beta_M}{\sin^2 \phi} \right] d\phi,
\]

where $\mathcal{M}_{\gamma_i}$ is the MGF for the distribution of the $i$th branch SNR $\gamma_i$ and $\alpha_M$ and $\beta_M$ are functions of the modulation such that in AWGN, $P_s \approx \alpha_M Q(\sqrt{\beta_M \gamma_s})$.

4. Transmit Diversity

- When channel known at transmitter, similar to receiver diversity. Get same array and diversity gain.
- When channel unknown at transmitter, for 2 TX antennas can use the Alamouti scheme over two symbol times to obtain full diversity gain, but no array gain. This scheme is part of various wireless standards but is hard to generalize to more than 2 antennas.

Main Points

- SC vs. MRC offer different levels of complexity vs. performance.
- Performance analysis of MRC greatly simplified using MGF approach.
- Transmit diversity for known channel gains has same performance as receiver diversity.