EE359 – Lecture 12 Outline

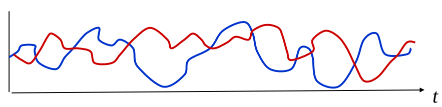
- Announcements
  - Midterm announcements
  - HW due Friday at 5pm (no late HWs)
  - No HW next week (practice MTs)
  - 2hr bonus lecture wk of 11/30 (no reg. lec. W 12/2)
- Selection Combining and its Performance
- Maximal Ratio Combining
- MGF Approach for Performance of MRC
- EGC
- Transmit Diversity

Midterm Announcements

- Midterm Wed Nov. 4, 8:45-10:45a in this rm.
  - Open book/notes (bring textbook/calculators)
  - Covers Chapters 1-7 (through today's lecture)
- Review Session Sunday 4-5:30pm, rm TBD
- Extra OHs
  - Me: Friday, Monday, Tuesday 2-3pm,
  - Yao: TBD
- Midterms from past 3 MTs posted
  - 10 bonus points for "taking" a practice exam
  - Solns for all exams given when you turn in practice exam

Review of Last Lecture

- Combined average and outage P_s
- P_s due to Doppler and ISI
- Introduction to Diversity
  - Send same bits over independent fading paths
    - Independent fading paths obtained by time, space, frequency, or polarization diversity
  - Combine paths to mitigate fading effects



Combining Techniques

- Selection Combining
  - Fading path with highest gain used
- Maximal Ratio Combining
  - All paths cophased and summed with optimal weighting to maximize combiner output SNR
- Equal Gain Combining
  - All paths cophased and summed with equal weighting
- Array/Diversity gain
  - Array gain is from noise averaging (AWGN and fading)
  - Diversity gain is change in BER slope (fading)

Selection Combining

- Selects the path with the highest gain
- Combiner SNR is the maximum of the branch SNRs.
- CDF easy to obtain, pdf found by differentiating.
- Diminishing returns with number of antennas.
- Can get up to about 20 dB of gain.

MRC and its Performance

- With MRC, $\gamma_\Sigma=\Sigma\gamma_i$ for branch SNRs γ_i
  - Optimal technique to maximize output SNR
  - Yields 20-40 dB performance gains
  - Distribution of γ_Σ hard to obtain
- Standard average BER calculation

$$\bar{P}_b=\int P_b(\gamma_\Sigma)p(\gamma_\Sigma)d\gamma_\Sigma=\int\int\ldots\int P_b(\gamma_\Sigma)p(\gamma_1)*p(\gamma_2)*\ldots*p(\gamma_M)d\gamma_1 d\gamma_2\ldots d\gamma_M$$

  - Hard to obtain in closed form
  - Integral often diverges
- MGF Approach

$$\bar{P}_b=\frac{1}{\pi}\int_0^{.5\pi}\prod_{i=1}^{M}\mathcal{M}_i\left[\frac{-g}{\sin^2\varphi};\gamma_i\right]d\varphi$$

EGC and Transmit Diversity

- EGQ simpler than MRC
  - Harder to analyze
  - Performance about 1 dB worse than MRC
- Transmit diversity
  - With channel knowledge, similar to receiver diversity, same array / diversity gain
  - Without channel knowledge, can obtain diversity gain through Alamouti scheme: works over 2 consecutive symbols

Main Points

- Diversity typically entails some penalty in terms of rate, bandwidth, complexity, or size.
- Techniques trade complexity for performance.
  - MRC yields 20-40 dB gain, SC around 20 dB.
- Analysis of MRC simplified using MGF approach
- EGC easier to implement than MRC: hard to analyze.
  - Performance about 1 dB worse than MRC
- Transmit diversity can obtain diversity gain even without channel information at transmitter.