Optimizing the Transmit Power for Slow Fading Channels

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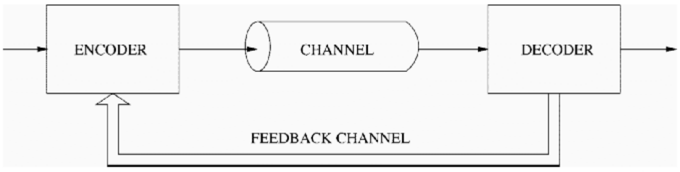
Key Ideas

- Goal
    - Design a optimal **close-loop finite-state power control (PC)** policy for slow fading channels.



- Control Policies
    - Define the “**cost**” of the result of PC with its “**constraint**”.
    - Find a method to **minimize** the cost.
    - This method leads to the desired PC strategy.

Cost & Constraint

- Cost: average BER with channel statistics $p(\gamma)$.

$$\sum_{i=1}^{K}\int_{\Gamma_i} p(\gamma)P_b(\gamma,S_i)d\gamma.$$

Γ_i : the i^{th} interval of the received SNR (per bit).

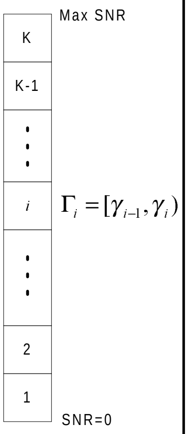
K : total state number.

$P_b(\gamma)$: the BER with the received SNR $=\gamma$.

S_i : normalized transmit power in state i.

- Constraint: finite average transmission power.

$$\sum_{i=1}^{K}\int_{\Gamma_i} p(\gamma)S_i d\gamma = 1.$$



- **Lagrange multipliers method** and **Lloyd algorithm** are used to find the minimum result.

Numerical Results

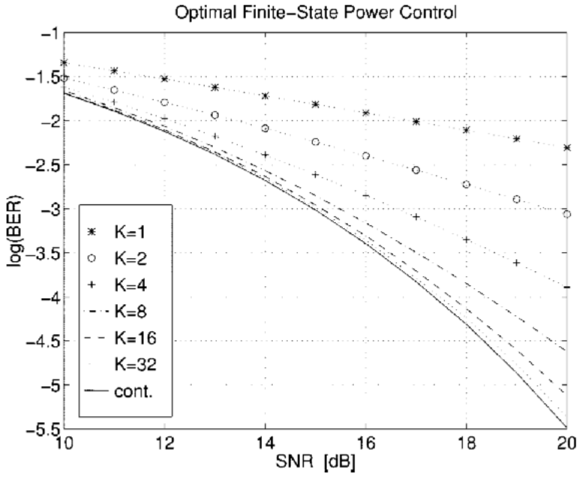


Fig. 2. BER using the optimum finite-state power control policy.

Numerical Results

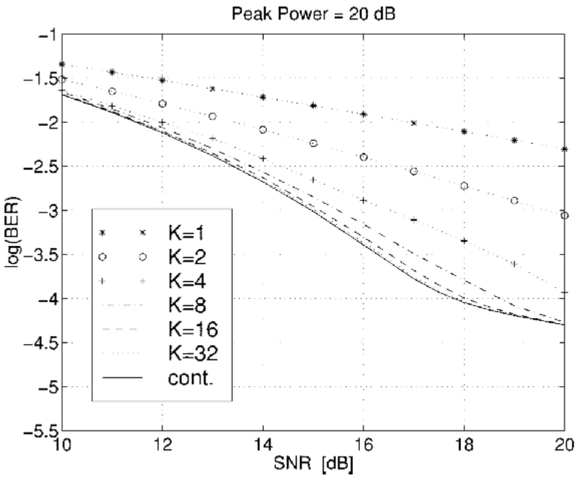
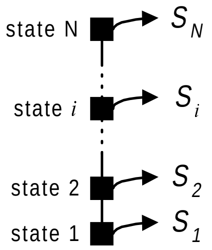


Fig. 5. BER using the optimum finite-state power control policy with peak power ≤ 100× average power.

Dynamic Programming Approach

- Key idea of DP: **Principle of Optimality**.
- Find the best mapping between the received SNR and the allocated transmit power, i.e., find the minimum cost of the state sequences.



- Implementation: Viterbi algorithm.

[REF] Control and System Theory, v.7 – Principles of Dynamic Programming.
R. E. Larson and J. L. Casti, 1978.

Numerical Results

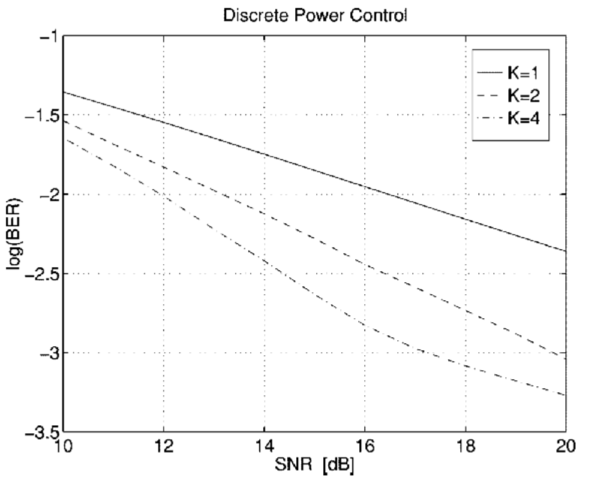


Fig. 7. Average BER for finite-state power control policies. K denotes the number of states with $K = 1$ corresponding to fixed transmit power. The peak-to-average transmit power was constrained to be less than 10 dB.

Numerical Results

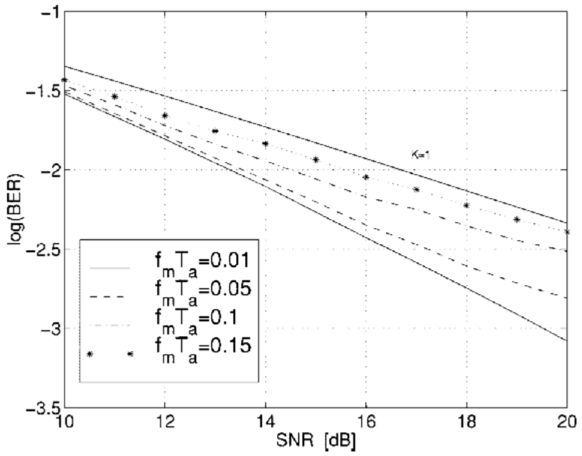


Fig. 8. Average BER for two-state power control policies. The peak-to-average transmit power ratio is 10 dB. The solid line (marked $K = 1$) corresponds to the constant transmit power policy.

Conclusions

- This paper indicates a direction to measure the effect of the PC policy.
- It is also interesting to introduce the concept of DP to make it more adaptive.
- Some issues of this paper…
  - The approach requires the perfect knowledge of the fading CH.
  - The feedback CH does not consider the effect of fading.
  - The adaptation period is still a critical parameter.
  - The "optimality" and "complexity" have to be justified if the effect of multiple access is considered.