MPOE Prefiltering and MRT Beamforming for DS-CDMA Systems

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Organization

1. Motivation for Prefiltering

2. MPOE Prefiltering
   System model
   Problem formulation
   Results

3. MRT Diversity
   Motivation
   System model
   Problem formulation
   Results
DS-CDMA Limited by:

1. MAI Multiple users
2. ISI Multipath Channel

- Multi-user signal processing overcomes MAI + ISI
- Difficult to implement in handsets
- Ideally suitable for uplink transmission
- Prefiltering provides a way for downlink transmission
System model

1. FIR filter
2. What is the criterion for design
MMSE optimal for AWGN channels.
\[ y = x + \eta \]

MPOE significantly better than MMSE in interference [1]
\[ y = h \otimes x + \eta \]

We develop prefilter to minimize probability of error in mobile receiver

FIR filter with complete channel knowledge
Conditional probability of error is formulated.

1. Since base station knows tx bits  
2. Provides Linear complexity [1]

Conditional probability of error expression in AWGN

\[ P_{E|B[i]}[i] = Q \left( \frac{b_u[i] \mu y_u^R|B[i][i]}{\sigma y_u^R|B[i][i]} \right) = Q \left( \frac{b_u[i] \mu y_u^R|B[i][i]}{\sigma \sqrt{\frac{N}{2}}} \right) \]

\[ y_u[i] = \sum_{k=0}^{N-1} s_{uk} \sum_{m=0}^{l_u} h_u[m][j_1] \sum_{l=0}^{L_x-1} z[l][j_2] \sum_{v=1}^{U} A_v b_v[j_2] \tilde{s}_v[jN + k - m - l] + \sum_{k=0}^{N-1} s_{uk} \eta_u[iN + k] \]

\[ z[.] [i + 1] = z[.] [i] - \mu \frac{\partial P_{EJ}}{\partial z[.] [i]} \]  
Simple gradient search is used
How to improve the performance further

- Diversity techniques can be used to improve performance.

- Instead of transmitting the signal through one channel, we send it through $M$ different channels.

- MRT is suitable
  - Does not require complex receiver
  - Does not boost the transmit power
Since the knowledge of the channel is assumed, we can take further advantage of this information

MRT provides full transmit antenna diversity when the channel information is available

Channel estimation is not feasible at the receiver, hence STBC is not considered

The beamforming weights are calculated adaptively
System model MRT Beamforming

Joint Prefilter

$z[n]$

Matched filter receiver of 1st user

Matched filter receiver of $u^{th}$ user

Matched filter receiver of $U^{th}$ user

Multipath wireless channel

Sampling at $T_c$

User 1

User $U$

$w_{1m}[n]

$w_{um}[n]

$w_{U2}[n]

$w_{U1}[n]

$w_{11}[n]

$w_{12}[n]

$w_{1M}[n]

$w_{U1}[n]

$w_{U2}[n]

$w_{UM}[n]

$\hat{x}_{11}[n]

$\hat{x}_{12}[n]

$\hat{x}_{1M}[n]

$\hat{x}_{U1}[n]

$\hat{x}_{U2}[n]

$\hat{x}_{UM}[n]

$\hat{x}[n]

$\hat{x}_1[n]

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The signal total signal

\[ \hat{x}[n] = \left( \sum_{u=1}^{U} \sum_{m=1}^{M} A_u b_u [nN] \tilde{s}_u[n] w_{um} [n] \right) \otimes z[.] [n] \]

After simple manipulation

\[ \hat{x}[n] = \left( \sum_{u=1}^{U} A_u b_u [nN] \tilde{s}_u[n] w_{u1} [n] \right) \otimes z[.] [n] \]

\[ \ldots + \left( \sum_{u=1}^{U} A_u b_u [nN] \tilde{s}_u[n] w_{uM} [n] \right) \otimes z[.] [n] \]

Signal transmitted from MRT m is

\[ \ddot{x}_m[n] = \left( \sum_{u=1}^{U} A_u b_u [nN] \tilde{s}_u[n] w_{um} [n] \right) \otimes z[.] [n] \]
Simulation parameters

3. Number of users 4 (U)
4. Chip gain 128 (N)
5. Correlation coefficients of PN code (0.1)
6. Channel complex Gaussian mean 0.5 & variance 0.1655
7. Channel FIR filter length 5
8. Prefilter length 4
The diagram illustrates the BER (bit error rate) performance across different SNR (signal-to-noise ratio) levels. The x-axis represents the SNR in dB, while the y-axis shows the BER. Various lines and markers represent different prefiltering techniques:

- MMSE Joint Prefiltering
- MPOE Joint Prefiltering
- MMSE Individual Prefiltering
- MPOE Individual Prefiltering

As the SNR increases, the BER decreases, indicating improved performance. The curve positions and slopes vary, reflecting the effectiveness of each prefiltering method under different SNR conditions.
Conclusion

- MPOE and MMSE prefiltering for DS-CDMA systems under a general channel conditions.
- MPOE prefilter is superior to that of MMSE prefilter
- The performance of the proposed system further increased by using MRT beamforming
Thanks