Enhancing ZF-DPC Performance with Receiver Processing

Young-Su Ryu
fernwehist@gmail.com
2015.06.05
Introduction

- Multiple-input Multiple-output (MIMO)
  - Achieve superior data rates
  - Data rate of multiuser MIMO (MU-MIMO) is dependent on the precoder design at the transmitter

- Precoding
  - A signal processing before transmission to provide high spectral efficiency
  - Dirty paper coding (DPC)
    - Non-linear algorithm to achieve MIMO broadcast channel (BC) capacity
    - Zero-forcing DPC (ZF-DPC) is a sub-optimal

- Enhanced ZF-DPC Performance
  - Utilizing the multiple-access channel (MAC)-BC duality
MU-MIMO BC

- Single base station (BS) and $K$ user equipment (UE)

- $N_t$: BS antennas
- $N_{k,r}$: $k^{th}$ user antennas
- $N_R$: total receive antennas
MU-MIMO BC (cont’d)

- **Downlink channel** $\mathbf{H}$
  - The channel matrix is $N_R \times N_t$
  - $\mathbf{H}_k$ denote the $N_{k,r} \times N_t$ channel gain matrix between BS and $k^{th}$ user
  
  $$\mathbf{H} = [\mathbf{H}_1^T \mathbf{H}_1^T \ldots \mathbf{H}_k^T]^T$$

- **Input symbol vector** $\mathbf{a}$
  - $\mathbf{a}_k$ denote the input vector for $k^{th}$ user
  
  $$\mathbf{a} = [\mathbf{a}_1^T \mathbf{a}_1^T \ldots \mathbf{a}_k^T]^T$$

- **Noise vector** $\mathbf{z}$

- **Received signal** $\mathbf{y}$
  
  $$\mathbf{y} = \mathbf{H}\mathbf{a} + \mathbf{z}$$
ZF-DPC Precoding

BS performs the LQ-factorization of the downlink channel matrix

\[ H = LQ \]

- \( L \): lower triangular matrix
- \( Q \): unitary matrix

Precoding filter

\[ F : Q^H \]

\[ B : GL \]

- \( I \): identical matrix
- \( B - I \):
  - \( L : [l_{ij}] \)
  - \( G : [g_{ii} = l_{ii}^{-1}] \)
ZF-DPC Precoding (cont’d)

W: receive filter

<Multi-user MIMO System Model>
Proposed ZF-DPC Algorithm (1)

**ZF-DPC eRxP Algorithm**

- $H_k^{(1)} := H_k, \Phi_k^{(1)} = 0$

- $H_k^{(n+1)} := H_k^{(n)} \left( \sum_{m=1}^{K} H_k^{(n)H} \Phi_k^{(1)} H_k^{(n)} + I \right)^{-1/2}$

- Perform SVD-factorization
  
  $H_k^{(n+1)} := U_k^{(n)} S_k^{(n)} V_k^{(n)}$

- Compute power allocation matrices $\Gamma_k^{(n+1)}$ by performing water-filling across the singular values $S_k^{(n+1)}$
  
  $\Phi_k^{(n+1)} := U_k^{(n+1)} \Gamma_k^{(n)} U_k^{(n+1)H}$

- Set Rx filters
  
  $W_k := U_k^{(n)H}$
Proposed ZF-DPC Algorithm (2)

ZF-DPC eRxP Algorithm (cont’d)

- Compute effective downlink channel
  \[
  \tilde{H} = \begin{bmatrix}
  (W_1H_1)^T \\
  (W_2H_2)^T \\
  \vdots \\
  (W_KH_K)^T
  \end{bmatrix}
  \]

- Iteration
- Compute ZF-DPC filters
Simulation Result

**ZF-DPC eRxp Simulation Results**

- Flat Rayleigh fading channel and additive white Gaussian noise with zero mean and unity variance
- The channel is assumed to be perfectly known both at the receivers

*Cumulative density function of achievable sum capacity at SNR=5 and 15 dB*
Conclusion

Presented a novel ZF-DPC transceiver design existing ZF-DPC based algorithms

Simulation results validate the performance improvement offered by the proposed technique which nearly achieves MIMO BC capacity for Rayleigh fading channels.
Thank you for giving your attention!