Channel Quantization and Prediction for MIMO-BC with Limited Feedback

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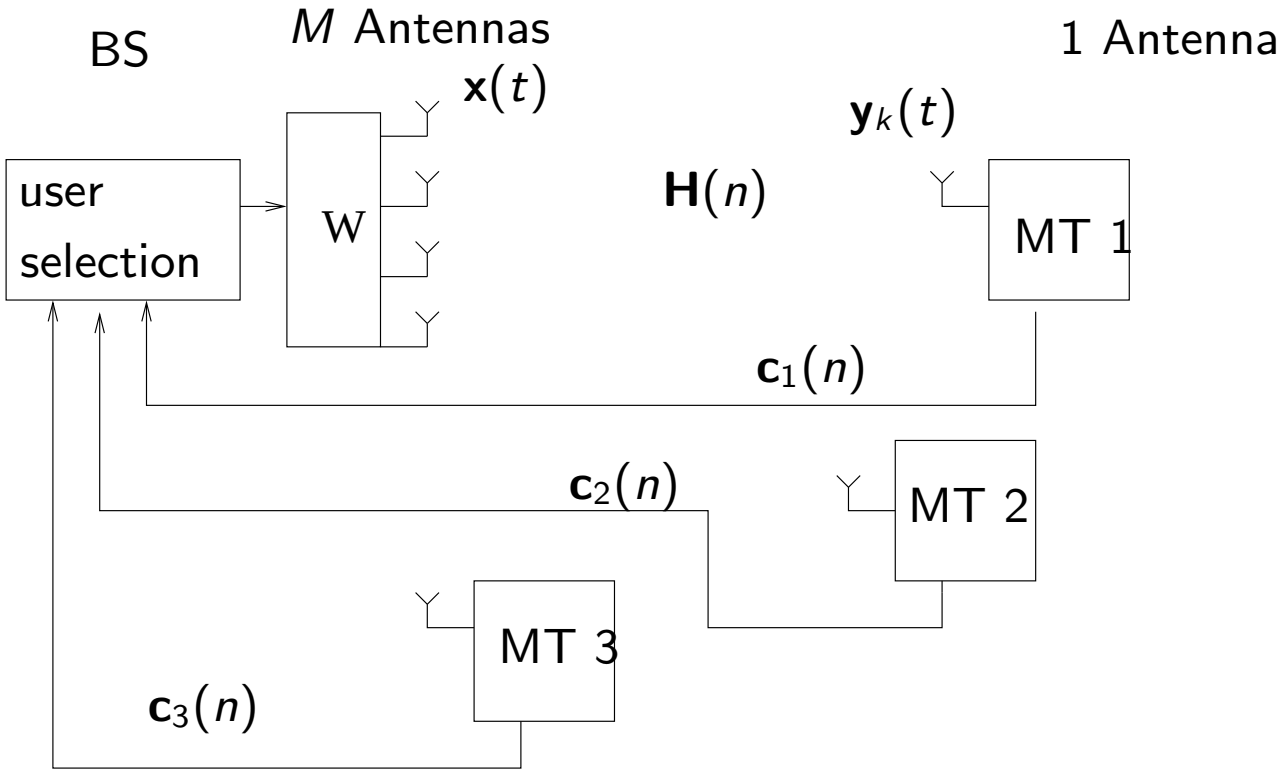
July 2008

Object

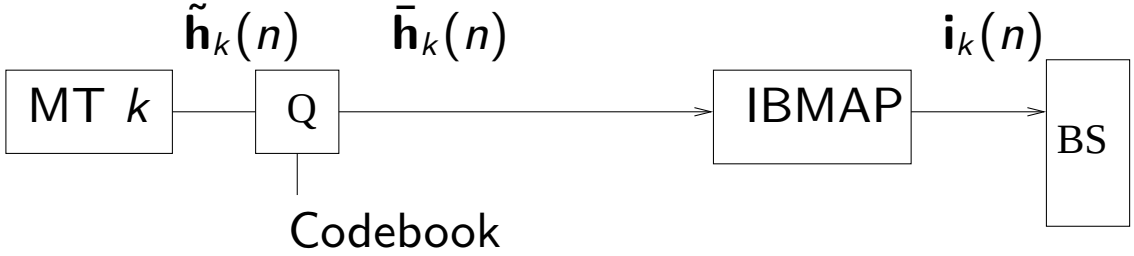
- Setting:
  - Multiuser downlink cellular environment;
  - BS equipped with M antennas;
  - Opportunistic user selection with QoS requirements;
  - Partial channel state information at the transmitter side (CSIT) provided by a feedback channel.
- Objective:
  - Investigation of joint techniques of FB signalling and channel prediction to achieve the highest weighted sum rate.

System model



K MTs

Feedback channel model



- Error free, zero delay, low rate feedback channel;
- MTs perfectly estimate the channel vector;
- MTs quantize the normalized channel vector $\tilde{\mathbf{h}}_k(n) = \frac{\mathbf{h}_k(nT)}{||\mathbf{h}_k(nT)||^2}$ according to a codebook $\mathcal{C}$. T is the time slot.
- In each time slot, MTs feed back a partial CSI, which is used by the BS to get the reconstructed channel $\bar{\mathbf{h}}_k(n)$ and schedule downlink transmission;

CDI Feedback

Standard Approach: Random vector quantizer (RVQ) MT feeds back the CDI at each slot The codebook is a set of 2^b vectors randomly chosen from an isotropic distribution on the M-dimensional unit sphere.

We propose a predictive strategy, exploiting the channel correlation in time domain. The optimum MMSE first order predictor is an holder; MT feeds back the prediction error.

Predictive Quantization strategy

Idea: quantizing the rotation on the unit sphere of the predicted vector. MT k first changes the space coordinates of the CVs from $[h_k^{(p)}(n) I_M]$ to the canonical basis; then it feeds back a quantized version of $\tilde{\mathbf{h}}_k(n)$ projected in the canonical basis. The BS receives the codeword c and performs a change of basis from the canonical one to $[h_k^{(p)}(n) I_M]$; the resulting vector is called reconstructed vector.

Codebook design

To design the codebook the LBG algorithm is used with metric

$$\max_{\mathcal{C}} \mathrm{E}\left[|\tilde{\mathbf{h}}_k \bar{\mathbf{h}}_k^*|^2\right] \tag{1}$$

Scenario

- Channel is time variant frequency selective Rayleigh fading: 3GPP spatial model, carrier frequency 2 GHz and bandwidth 5 MHz;
- BS equipped with M antennas and performs ZF beamforming;
- $K(> M)$ users to serve, each equipped with a single antenna;
- Distance between adjacent antennas is enough to have i.i.d. channel vectors;
- Single carrier transmission is performed in time slots of size T;
- Greedy user selection algorithm

Feedback techniques as a function of the FB rate

SNR = 15 dB