Weighted Sum Throughput Maximization for Coordinated Multicell Multicasting with User Selection

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I. MOTIVATION AND BACKGROUND

Physical layer multicasting has received much attention in recent years due to the increasing demand for wireless downlink applications. In these applications, a common message is to be sent from the base-station (BS) to a group of users that are demanding the same service. By assuming that all users are served simultaneously, the multicast beamforming problem was considered in [2] for a system that consists of a single multi-antenna BS transmitting to a single multicast group. The problem was further extended to systems with multiple multicast groups in [3]. However, in these cases, the rate transmitted by the BS must be low enough to ensure that all users decode successfully, which limits the throughput of the system. Yet, this effect can be alleviated by employing the so-called opportunistic scheduling multicasting (OMS) scheme [1], where only a subset of users is served in each time slot.

In this work, we propose an efficient user selection and transmit signal design for OMS in multicell networks with multiple multicast groups. The proposed designs are based on the Weighted Sum Throughput Maximization (WSTM) criterion, where the weighted sum throughput among all multicast groups is maximized.

II. MAIN RESULTS

Let us consider a downlink multicell network with $B$ BSs, each equipped with $N_t$ antennas, and $K$ single-antenna users. The $K$ users are divided into $G$ multicast groups $G_1, ..., G_G$, where users in the same group are interested in receiving the same multicast message. Moreover, let $B_i$ be the set of BSs that are serving group $G_i$. Let $s_i = [s_{1,i}^H, s_{2,i}^H, ..., s_{N_t,i}^H]^H$, where $s_{b,i} = 0$ for $b \notin B_i$, be the signal vector transmitted from all BSs to group $i$. The signal received by user $k \in G_i$ is

$$y_k = h_k^H s_i + h_k^H \sum_{j \neq i} s_j + n_k$$

where $h_k = [h_{1,k}^H, h_{2,k}^H, ..., h_{N_t,k}^H]^H$ of user $k$ with $h_{b,k}$ being the $N_t \times 1$ channel vector between BS $b$ and user $k$ and $n_k \sim CN(0, \sigma_n^2)$ is the additive complex Gaussian noise at user $k$.

In the proposed WSTM design, the parameters are chosen to maximize the weighted sum throughput among all multicast groups. The optimization problem is formulated as follows:

$$\max_{\{A_i\}_{i=1}^G} \max_{\{Q_i\}_{i=1}^G} \sum_{i=1}^G \beta_i |A_i| \min_{k \in A_i} \log_2 \left( 1 + \frac{\text{tr}(Q_i h_k h_k^H)}{\sum_{j \neq i} \text{tr}(Q_j h_k h_k^H) + \sigma_n^2} \right)$$

subject to

$$\sum_{i=1}^G \text{tr}(\{Q_i\}_{b,b'}) \leq P_b, \forall b, Q_i \succeq 0, \forall i,$$

$$\{Q_i\}_{b,b'} = 0_{N_t \times N_t}, \text{ for } b \notin B_i \text{ or } b' \notin B_i,$$

where $Q_i \triangleq E[s_i s_i^H]$ is the covariance matrix formed with the $(b,b')$-th block entry (i.e., denoted by $Q_i(b,b')$) equal to $E[s_{b,i} s_{b,i}^H]$ if $b, b' \in B_i$ and equal to zero if $b \notin B_i$ or $b' \notin B_i$.

The inner optimization over $\{Q_i\}_{i=1}^G$ is non-convex and, thus, is reformulated as a convex feasibility problem, which is solved using the bisection algorithm. The outer optimization over $\{A_i\}_{i=1}^G$ is combinatorial in nature, and, thus, rapidly becomes intractable as the number of users increases. We propose a suboptimal list elimination (LE) procedure to reduce the computational complexity of the problem. The LE procedure is initialized by selecting all users in each group. Then, the $M$ users with the worst SNR in each group are selected as candidate users. Each of these candidates is tested to see if their removal improves the weighted sum throughput.

Computer simulations in Fig. 1 show that the WSTM scheme outperforms both broadcast and unicast schemes.

REFERENCES