Joint Admission Control and Power Control with SINR Constraints in Cloud Radio Access Networks

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***Abstract*—We propose a joint admission control and power control algorithm by leveraging the matrix spectral radius characterization to tackle the infeasibility of the total power control minimization problem with SINR constraints.**

I. Preliminaries

We model the total power minimization problem with the SINR constraints as following:

$$\begin{array}{ll} \text{minimize} & \sum_l p_l \\ \text{subject to} & \mathsf{SINR}_l(\mathbf{p}) = \dfrac{G_{ll}p_l}{\sum_{j\neq l} G_{lj}p_j + \sigma_l} \geq \bar{\gamma}_l, \quad \forall l \\ & 0 \leq p_l \leq \bar{p}_l, \quad \forall l \\ \text{variables}: & \mathbf{p}. \end{array} \tag{1}$$

where $\bar{p}_l$ is the upper-bound of the transmit power for the l-th users, SINR_l is the signal-to-interference-plus-noise of the l-th users, and $\bar{\gamma}_l$ is a given SINR threshold that represents the l-th user's quality of service requirement.

When (1) is feasible, we can solve it by rewriting (1) into a linear program:

$$\begin{array}{ll} \text{minimize} & \mathbf{1}^\top \mathbf{p} \\ \text{subject to} & (\mathbf{I} - \mathrm{diag}(\bar{\boldsymbol{\gamma}})\mathbf{F})\mathbf{p} \geq \mathrm{diag}(\bar{\boldsymbol{\gamma}})\mathbf{v}, \\ & \mathbf{0} \leq \mathbf{p} \leq \bar{\mathbf{p}}, \\ \text{variables}: & \mathbf{p}. \end{array} \tag{2}$$

where $\mathbf{I}$ is the identity matrix, $\mathbf{F}$ is the channel gain matrix where $F_{lj} = G_{lj}/G_{ll}$ and $F_{ll} = 0$, and $\mathbf{v}$ is the noise vector with $v_l = \sigma_l/G_{ll}$. In addition, [1] can solve (2) in a distributed manner:

$$p_l(t+1) = \min\left\{\frac{\bar{\gamma}_l}{\mathsf{SINR}_l(\mathbf{p}(t))}p_l(t), \bar{p}_l\right\}, \quad \forall l. \tag{3}$$

II. Joint Admission Control for Infeasibility

When (1) is infeasible, we need to choose the minimum number of users to be removed from the network. Therefore, we formulate an optimization problem related to (1) by adding auxiliary variables q_l to the SINR constraint for each l-th user:

$$\begin{array}{ll} \text{minimize} & \|\mathbf{q}\|_0 \\ \text{subject to} & \dfrac{\bar{\gamma}_l}{\mathsf{SINR}_l(\mathbf{p})} \leq 1 + q_l, \quad \forall l \\ & \mathbf{0} \leq \mathbf{p} \leq \bar{\mathbf{p}}, \\ \text{variables}: & \mathbf{p}, \mathbf{q}, \end{array} \tag{4}$$

where $\mathbf{q}$ can be interpreted as an indicator of infeasibility that also has a physical meaning of removal price, and the objective function $\|\mathbf{q}\|_0$ is the ℓ_0 norm that measures the cardinality of $\mathbf{q}$.

Now, [2] can solve (4) in a distributed manner. Furthermore, we propose the following admission control and power control algorithm by leveraging the matrix spectral radius characterization ρ:

Algorithm 1 (Joint Access Control):

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1) Add the j-th user until $\rho \geq 1$:

$$j = \arg\min_{l=1,\cdots,L} \rho(\mathrm{diag}(\bar{\boldsymbol{\gamma}}_l)\mathbf{F}_l). \tag{5}$$

2) Run the algorithm in [2] to check the feasibility:

$$p_l(k+1) = \min\left\{\frac{\bar{\gamma}_l}{\max\{\nu_l(k), 1\}\mathsf{SINR}_l(\mathbf{p}(k))}p_l(k), \bar{p}_l\right\}. \tag{6}$$

Figure 1 shows that our Algorithm 1 performs well in comparison with existing removal algorithm to resolve system infeasibility.

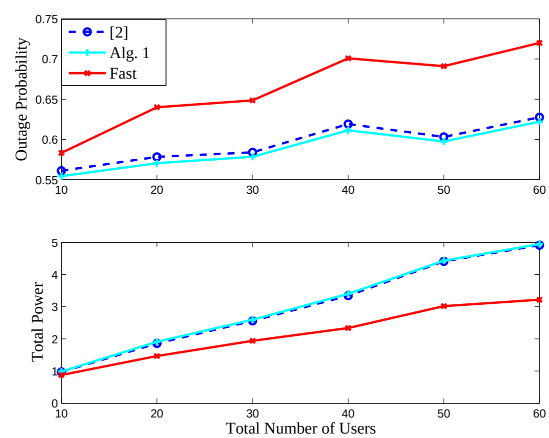

Fig. 1. Average outage probability and average total energy consumption versus total number of users.

References

[1] R. D. Yates, "A framework for uplink power control in cellular radio systems," *IEEE Journal on Selected Areas in Communications*, vol. 13, no. 7, pp. 1341–1347, Sep. 1995.

[2] X. Zhai, L. Zheng, and C. W. Tan, "Energy-infeasibility tradeoff in cognitive radio networks: Price-driven spectrum access algorithms," *IEEE Journal on Selected Areas in Communications*, vol. 32, no. 3, pp. 528–538, Mar. 2014.