

# 1 Game and System Setup

This game considers a wireless communications network which includes a both macro cell and femto cell users.

## 1.1 Players

Individual femto cells are the players in this game. Here each player  $f \in \{1...F\}$  is considered to have a number of antennas  $T_f$  with which to transmit to  $K_f$  femto cell users.

In this setting femto cells are assumed to be spaced far apart in distance permitting the simplification that femto cell  $f$  cause no interference to the users of femto cell  $j \in \{1...F\} \setminus f$

Femto base stations with multiple antennas can beamform their transmission with transformation  $\mathbf{U}_f \in \mathbb{C}_{T_f \times L_f}$ .

Femto base station  $f$  has power constraint  $\sum_{i=1}^{L_f} p_{f,i} \leq P_f^{Total}$ .

Femto base stations are assumed to have a utility function  $U_f()$  based upon the quality of service provided to its users.

Macro Cell user  $m \in \{1...M\}$  experiences receiver interference to due transmission by femto cell base stations. These macro cell users have limits to the amount of interference they will tolerate  $\sum_{f=1}^F \mathbf{p}_f^t \tilde{\mathbf{h}}_m^T \mathbf{U}_f \leq I_m^{Threshold}$ .

Femto base station  $f$  is assumed to have full channel information ( $\mathbf{H}_f$ ) for all user with which it transmits. The received signal for user  $j$  of femto base station  $f$  experiences the inner product of  $\mathbf{h}_{fj}^H \mathbf{u}_{fj}$

Femto cell  $f$  is assumed to have full channel information ( $\tilde{H}_f$ ) for all user with which it interferes .

Users of femto cell  $f$  have SINR  $\gamma_{f,i} = p_{f,i} |\mathbf{h}_{fi}^H \mathbf{u}_{fi}|^2 / \sigma_n^2$  *oise*  $i \in \{1...L_f\}$  with AWGN  $\sim \mathcal{N}(0, \sigma_n^2)$

## 1.2 Optimization Problem

Each player  $f$  attempts to maximize utility function  $U_f()$  while playing a strategy that falls in the region constrained by the interference caused to macro cell users.

## 2 Solving