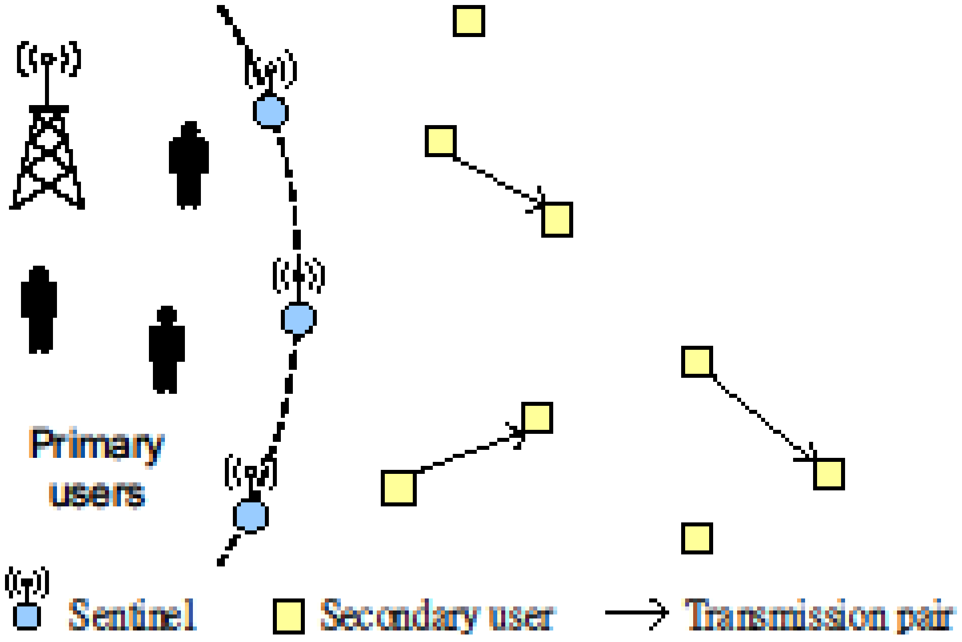
# Interference Control for Spectrum Sharing

Spectrum sharing in cognitive radio network

# Cognitive Network

- Primary users and secondary users coexist
- Hybrid of overlay and underlay Spectrum sharing
- Power control



# Problem Formulation

- Interference temperature at the sentinels

$$\sum_{i \in \mathrm{V}} X_i G_{ik} P_i \le \overline{\eta}_k, \ \forall k \in \mathrm{A}$$

- Link quality of secondary users

$$\gamma_i \ge \overline{\gamma}_i, \ \overline{\gamma}_i = \max\left\{ \frac{2^{r_i/w} - 1}{a_i}, \frac{\left\lfloor Q^{-1}\left(e_i / b_i\right)\right\rfloor}{c_i} \right\}, \ \forall i \in \mathrm{V}$$

- available transmission power of secondary users

$$0 \le P_i \le X_i \overline{P}_i, \ \forall i \in \mathrm{V}$$

- objective function

$$\underset{X,P}{\text{Maximize}} \ U(X,P) = \sum_{i \in \mathrm{V}} \log_2 \left( 1 + a_i \cdot \frac{X_i G_{i\bar{i}} P_i}{I_{\bar{i}}} \right)$$

# Relaxed Problem

- Soft admission ($X_i$ relaxed)

$$\underset{P}{\text{Maximize}}\ U(P) = \sum_{i \in \mathrm{V}} \log_2\left(1 + a_i \cdot \frac{G_{i\bar{i}} P_i}{I_{\bar{i}}}\right)$$

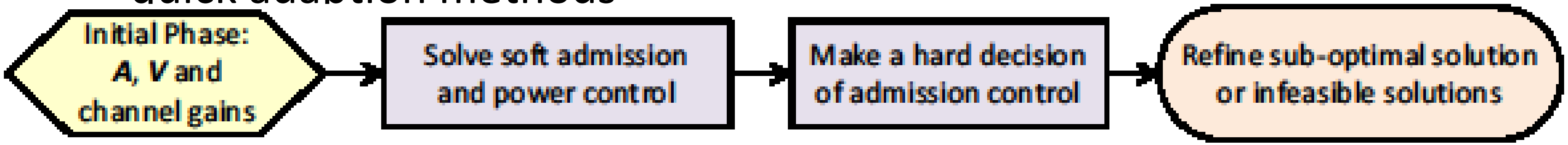
$$\sum_{i \in \mathrm{V}} G_{ik} P_i \le \overline{\eta}_k,\ \forall k \in \mathrm{A}$$

$$0 \le P_i \le \overline{P}_i,\ \forall i \in \mathrm{V}$$

- Hard decision

$$\gamma_i \ge \overline{\gamma}_i,\ \overline{\gamma}_i = \max\left\{\frac{2^{r_i/w} - 1}{a_i}, \frac{\left[Q^{-1}(e_i/b_i)\right]}{c_i}\right\},\ \forall i \in \mathrm{V}$$

- Refine sub-optimal solution
    - quick adaption methods



# Game Based Distributed Algorithms

- Game based model

$$\hat{U}_i\left(P\right)=U_i\left(P\right)-C_iP_i$$

- Designing price (Lagrange relaxation)

$$C_i=-\sum_{j\in V,\, j\neq i}\frac{\partial U_j\left(P^*\right)}{\partial P_i}+\sum_{k\in A}G_{ik}\lambda_k,\ i\in \mathrm{V}$$

- Best response

$$P_i^{\dagger}\left(\mathrm{P}\right)=\left[\frac{1}{C_i}-\frac{I_{\bar{i}}}{G_{i\bar{i}}}\right]_0^{\overline{P_i}}$$

- Straight forward distributed algorithm $P_i\left(t+1\right)=P_i^{\dagger}\left(P_i\left(t\right)\right)$

# Overall Design

- Intended movement
- Smoother movement

$$P_i\left(t+1\right)=P_i^{\dagger}\left(P_i\left(t\right)\right)$$

$$P_i\left(t+1\right)=\alpha\cdot P_i\left(t\right)-\left(1-\alpha\right)\cdot\left[\frac{1}{C_i}-\frac{I_{\bar{i}}}{G_{i\bar{i}}}\right]_0^{\hat{P}_i},\hat{P}=\max_{k\in A,\forall i\in V}\frac{\overline{\eta_k}}{\left|V\right|G_{ik}}$$

# Quick Adaption to Interference Margin

- Interference margin

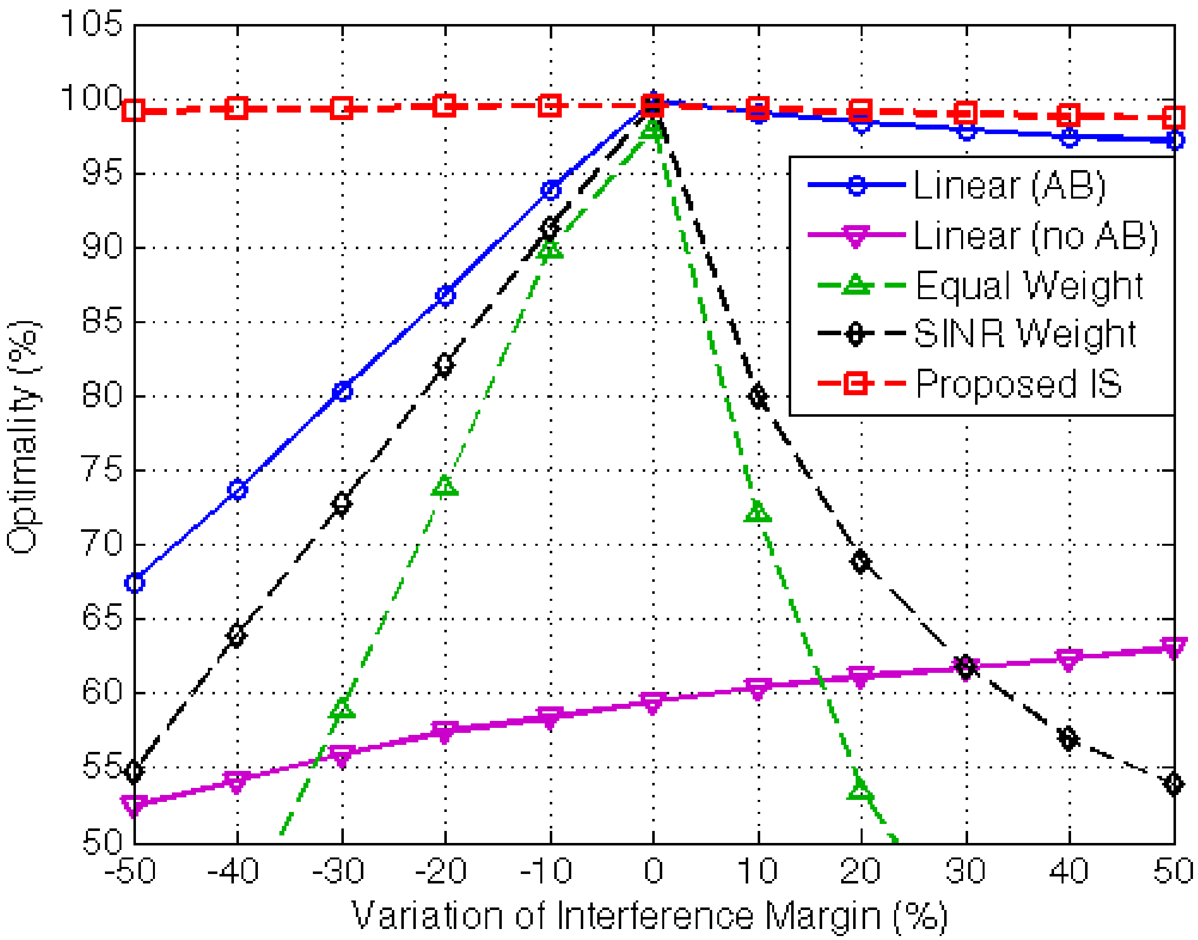
$$\Delta\eta = \min\left\{\overline{\eta_k} - \sum_{i\in V} G_{ik} X_i P_i\right\}$$

- Equal weights, SINR weights, proportional scaling

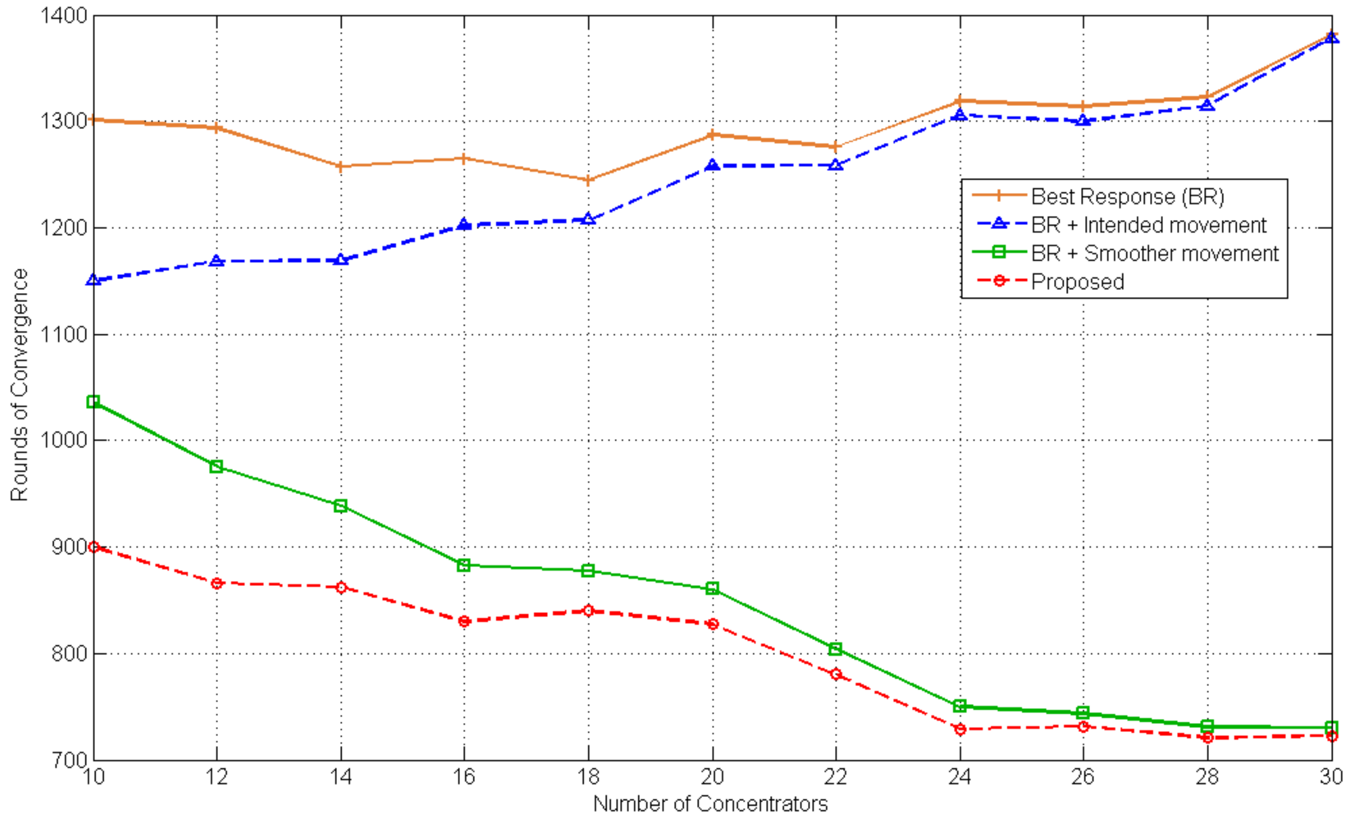
$$\Delta P_i = \frac{\beta_i \Delta\eta_{k^\dagger}}{G_{ik^\dagger}}, k^\dagger = \arg\min_{k\in A} \Delta\eta_k$$

$$\beta_i = \frac{G_{ik^\dagger} P_i}{\sum_{j\in W} G_{jk^\dagger} P_j}$$

# Adaptions to Margin Variation



# Rounds of Convergence to Number of T-pairs



# Performance to QOS of Primary Users