Centralized control schemes for wireless networks (e.g., wireless ad-hoc networks) could be practically difficult to implement:

- A central entity may not have access to the required information on the end users, especially in dynamically evolving systems.
- Centralized optimization procedures might be computationally involved.

Distributed approaches are more natural. Competition for network resources can be modeled as a noncooperative game leading to a robust and distributed control paradigm.

**Model**

- A finite set of mobiles, \( \mathcal{M} = \{1, \ldots, M\} \).
- **Fading** effect: A global channel state process \( H(t) \in \mathcal{H} = \{1, 2, \ldots, h\} \). Example of global effects may include common weather conditions in satellite communications, and thermal noise at the base station.
  - The state process is stationary (e.g., block-fading), state \( i \) is observed with probability \( \pi_i \).
  - Collision channel: Simultaneous transmissions collide and data is lost.
  - The average rate user \( m \) can sustain in state \( i \) (assuming no collision) is denoted by \( R_{mi}^{\ast} \).
  - Per-user average power constraint \( \bar{P}_m \).
  - We consider stationary strategies: \( p_m^i \) is the (stationary) transmission probability of user \( m \) at state \( i \).
  - Utilities capture tradeoff between power \( (P_m^m) \) and throughput \( (T_m^m) \): \( u_m(p_m^m) = T_m^m(p_m^m) - \lambda m P_m^m(p_m^m) \).

**Summary**

**Main Results**

- Characterization of the social welfare problem, and useful reduction of our game to a finite game.

  Let \( \pi_{\max} = \max_{i \in \mathcal{H}} \pi_i, P_{\min} = \min_{m \in \mathcal{M}} P_m^m \), and define a technology-related parameter: \( Q = \frac{\pi_{\max}}{P_{\min}} \).

  **Theorem 1.** Fix \( Q < 1 \). Then,
  1. The performance ratio between the best equilibrium and the social optimum is bounded above by \( (1-Q)^{-2} \).
  2. The performance of the worse equilibrium point could be arbitrarily bad.

  **Implication:** With finer quantization, equilibrium efficiency can be improved.

  **Theorem 2.** If \( R_m^m = R_i \) for all users \( m \), then the game is a potential game, which in our case implies convergence of best-response mechanism to an equilibrium point in finite time.

  We further show that under general rate values \( R_m^m \) the game is not a potential game.

**Future Work**

- Exploit the idea of projection onto a potential game in our framework.
- Partial correlation of the state processes.
- Multi-hop architectures.
- Additional channel models (e.g., CDMA)
- Convergence of dynamics with asynchronous updates

**Potential Games**

Potential games have desirable convergence properties.

- Thus, in order to guarantee convergence of simple myopic dynamics, a game can be projected onto a potential game.
- Ongoing research focuses on a general framework, in which the original user utilities are slightly modified (e.g., in the form of incentives) to form a potential game.