ΟΙΚΟΝΟΜΙΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ

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Incentives Based Power Control in Wireless Networks of Autonomous Entities with Various Degrees of Cooperation

1. Motivation

- "The number of mobile-connected devices will exceed the world's population in 2013", Cisco, Feb. 2013
- Map of Fon Wi-Fi APs in (part of) London, April 2013
- + All other APs + other wireless devices… →Too many devices coexist in the same area
- and compete for radio spectrum
  - (-) very limited resource
- The problem: (-) Too much interference
- The challenge: (How) Can we control it?

Map via corp.fon.com

2. On the Interference Mitigation in Wireless Networks

- Power control (PC): How to choose the transmission power to achieve a Quality of Service (QoS) target
- Some challenges for a successful power control algorithm [1]

Centralized — Distributed

TDMA/ FDMA/ CDMA — Uplink & Downlink

Voice & Data Links — Synchronous / Asynchronous

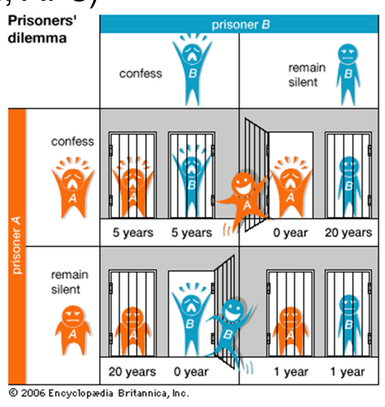
PC + BS Assignment — PC + Admission Control

Simple, Efficient, Fast

WCDMA3Gblogspot

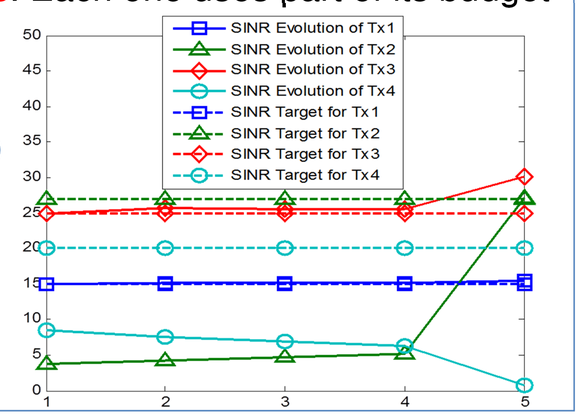
3. Power Control Using Game Theory

- We focus on scenarios where nodes have different QoS targets and (at least some of) them are autonomous (e.g., APs)
- We need distributed power control schemes
- Competition for resources among players= (non-cooperative) game theory
- Key Issues/Our Roadmap:
  - Has the game a Nash Equilibrium (NE)?
  - How can we find it?
  - Is it unique? If not, which to choose?
  - Is it (Pareto) efficient?
- Two indicative approaches follow



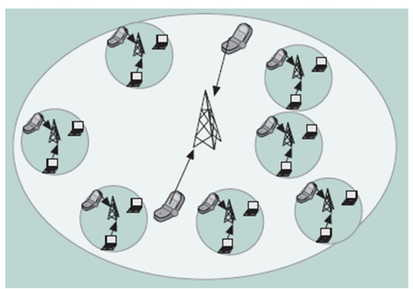
4. Negotiation-Based Distributed Power Control [2]

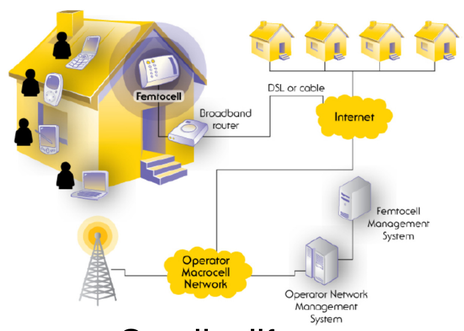
- We cannot dictate to an AP to power off/reduce its power!
- Unsatisfied links negotiate in pairs. Each one uses part of its budget to make an offer to the other



5. Non-Cooperative Power Control in Small Cell Networks

- Small cells are low-power APs that operate in licensed spectrum
- More devices…more interference!
- Two-tier small cell network (SCN):





Smallcellforum.org

6. Power Control Under Best Response Dynamics in Small Cell Networks [3]

- Heterogeneous nodes-heterogeneous utility functions
- Mobile Node: $U_i(P_i, \mathbf{P}_{-i}) = B_i \ln(1+\mathrm{SINR}_i)$ subject to: $0 \le P_i \le P_{\max}$ and $\mathrm{SINR}_i \le \gamma_i$
- Small Cell Node: $U_i(P_i, \mathbf{P}_{-i}) = B_i \ln(1+\mathrm{SINR}_i) - c_i P_i$ subject to: $0 \le P_i \le FP_{\max}$

$$\mathrm{SINR}_i = L\frac{G_{ii}P_i}{\sum_{j\neq i} G_{ji}P_j + n} = L\frac{G_{ii}P_i}{R_i} \rightarrow P_i(k+1) = \min\left\{P_{\max}, \gamma_i \frac{R_i(k)}{LG_{ii}}\right\}$$

- Iterative scheme: MNs PC SCNs PC→ $P_i(k+1) = \max\left\{0, \min\left\{\frac{B_i}{c_i} - \frac{R_i(k)}{LG_{ii}}, FP_{\max}\right\}\right\}$
- We show the existence and uniqueness of a NE in this scheme
- Interference mitigation in various scenarios is achieved

[1] V.G. Douros and G.C. Polyzos, "Review of Some Fundamental Approaches for Power Control in Wireless Networks," *Elsevier Computer Communications*, vol. 34, no. 13, pp. 1580-1592, August 2011.

[2] V.G. Douros, G.C. Polyzos and S. Toumpis, "Negotiation-Based Distributed Power Control in Wireless Networks with Autonomous Nodes," Proc. 73rd IEEE Vehicular Technology Conference (VTC2011-Spring), Budapest, Hungary, May 2011.

[3] V.G. Douros, S. Toumpis and G.C. Polyzos, "Power Control Under Best Response Dynamics for Interference Mitigation in a Two-Tier Femtocell Network," Proc. 8th International Workshop on Resource Allocation and Cooperation in Wireless Networks (RAWNET), Paderborn, Germany, May 2012.

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