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
   - The problem: (-) Too much interference
   - The challenge: (How) Can we control it?

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]

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
   - I achieved my QoS Target
   - 20% below my QoS Target
   - 40% below my QoS Target

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):

   - Heterogeneous nodes-heterogeneous utility functions
   - Mobile Node: $U_i(P_i, P_{-i}) = B_i \ln(1 + \text{SINR}_i)$ subject to $0 \leq P_i \leq P_{\text{max}}$ and $\text{SINR}_i \leq \gamma_i$
   - Small Cell Node: $U_i(P_i, P_{-i}) = B_i \ln(1 + \text{SINR}_i) - c_i P_i$ subject to $0 \leq P_i \leq P_{\text{max}}$
   - $\text{SINR}_i = \frac{C_i P_i}{\sum_j G_j P_j + n}$
   - Iterative scheme: MNs PC SCNs PC
   - We show the existence and uniqueness of a NE in this scheme
   - Interference mitigation in various scenarios is achieved

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