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

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1. Some Difficult Problems…

- Spectrum is a limited resource
- (-) Too much interference even in small topologies
- Limited battery life of wireless devices (crucial for uplink transmission)
- (-) Not so promising technological evolution towards that direction

2. …Demand Solutions

- Dynamic Spectrum Access
- Promising but still needs to combine with:
  - ✓ Channel Assignment
  - ✓ Directional Antennas
- Transmitter Power Control: smart choice of the transmission power to achieve a specific goal

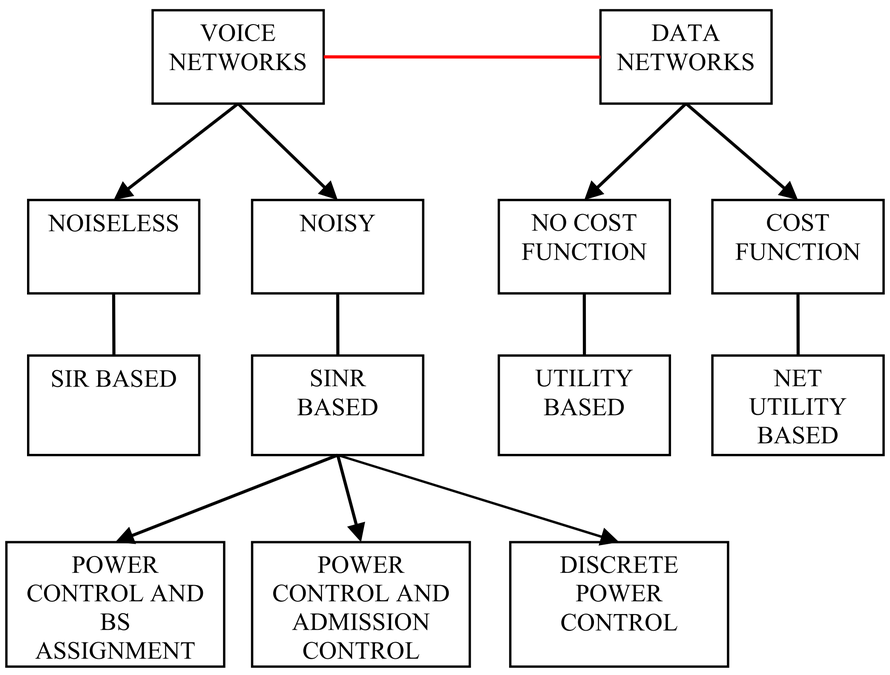
3. Why Transmitter Power Control?

- Easy to implement in practice (e.g. CDMA)
- More suitable to combat energy constraints
- Easy to combine with the other techniques
- Many previous successful works

4. Power Control so as to…

- Mitigate interference ↔ Increase network capacity
- Conserve energy ↔ Prolong battery life
- Adapt to channel variations ↔ Support QoS
- Greening the Internet
- All the above are fully dependent on SI(N)R

5. Some Fundamental Approaches on Power Control – The Big Picture

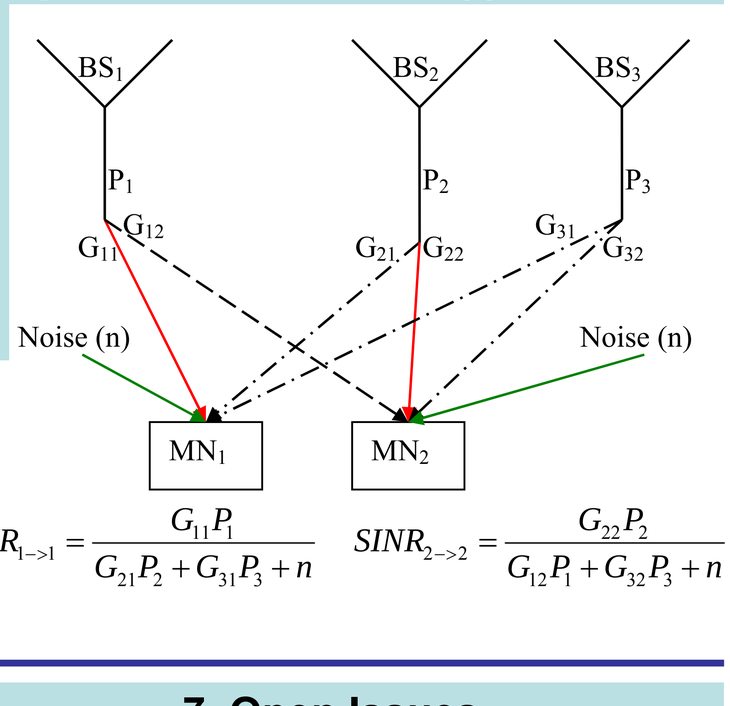


Demands/ Desires for a successful power control algorithm

Centralized — Distributed (Partially or Fully)
TDMA/ FDMA/ CDMA — Uplink & Downlink
Voice & Data Links — Synchronous / Asynchronous
Pmax — Discrete Powers
PC + BS Assignment — PC + Admission Control
Simple, Efficient, Fast

- *SIR Based Power Control*: Find a power vector that maximizes the minimum SIR and minimizes the maximum SIR of each link
- *SINR Based Power Control*: Find the minimum power vector so that each link has SINR over (or equal to) a predefined target
- *Utility Based Power Control*: Find a power vector that maximizes the utility function of each link
- *Net Utility Based Power Control*: Find a power vector that maximizes the net utility function (utility function – cost function) of each link
- (How) Could we integrate/ unify the above mentioned approaches?

- SI(N)R Based vs. (Net) Utility Based
- Simple vs. Supermodularity (Existence, Uniqueness NE)
- Hard SI(N)R targets vs. Soft SI(N)R targets
- One metric vs. More metrics
- Engineering vs. Economical



$$SINR_{1->1} = \frac{G_{11}P_1}{G_{21}P_2 + G_{31}P_3 + n} \qquad SINR_{2->2} = \frac{G_{22}P_2}{G_{12}P_1 + G_{32}P_3 + n}$$

6. Incentive Based Power Control

- In Traditional Power Control… Entities (APs, BSs, MNs) have a predefined target
- Moreover, they are always willing to follow a standard policy
- How to enforce (predefined) strategies or/ and targets to autonomous entities?
- By applying … incentive based power control, i.e. not only to find an optimal power control algorithm but also to provide the incentives to follow it!
- Key variation of our vision: Each entity chooses autonomously both its strategy and its target, which vary with the time, being in a dynamic environment
- I.e. from a set of algorithms each entity chooses the most suitable one to achieve its target each given time
- Incentives are crucial so as to influence the strategy or/and the target of other entities

7. Open Issues

- How do specific characteristics of each wireless network influence the degree of cooperation among the entities?
- Influence of a) network characteristics (delay, noise, fading) b) user profile (mobility model) c) algorithm "demands" (synchronization)… to the need for incentives for cooperation
- Discrete Power Control: Most works focus on continuous power adjustment. However, transition from continuous to discrete space is not always trivial!

[1] V. G. Douros and G. C. Polyzos, "A Review on Some Fundamental Approaches on Power Control in Cellular Networks" (under submission)

[2] V. G. Douros, P. A. Frangoudis, K. Katsaros and G. C. Polyzos, "Power Control in WLANs for Optimization of Social Fairness," Proc. 12th Pan-Hellenic Conference on Informatics (PCI 2008), Samos, Greece, August 2008)