Dynamic Spectrum Allocation for Cognitive Radios

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Promise of Cognitive Radios

- Cognitive radios are radio architectures in which the communication is not restricted to a fixed band
- Dynamically adapt its transmission to find and utilize holes in
  - Space
  - Time
  - Frequency

Cognitive radios require flexible market driven regulatory model for efficient spectrum use

Objectives

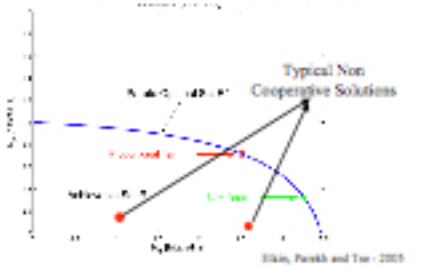
- Non Cooperative Models
- Cooperative Models
  - Sustaining cooperative and managing incentive
  - Performance of cooperative behavior
  - Common protocol for cooperation
- Regulatory insights

Use Cognitive Radios to move from conventional "command and control" spectrum usage model to flexible "spectrum common" model

Non-Cooperative Models

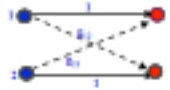
- Nodes treat each other as noise
- No transmitter or receiver cooperation
- Etkin et al. showed that the performance can be highly inefficient
- Investigate efficiency loss of non cooperative model and their dependence on system parameters (channel gains, power limitations)
- Investigate large system limits [Huang-Berry-Honig, 2006]

Typical Performance Loss



Non-Cooperative Model with Unknown channel gains

- Consider 2 x 2 Gaussian Interference channel, but with cross gains unknown.
- Model this channel as a Bayesian game

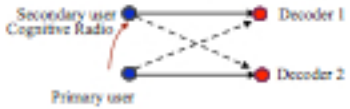


- The Nash Equilibrium is to split the power across all bands (uniform power profile)

Lack of knowledge about interference leads to inefficient solutions

Cooperation

- Cognitive radio overhears the primary user's transmission – it can cooperate with primary user
- Questions:
  - How do nodes discover if cooperation is beneficial?
  - How do nodes exploit gains from cooperation?
  - How do nodes manage/enforce cooperation?



Information Patterns for Cooperation

- How much information needs to be shared among devices to conclude that cooperation is beneficial?
- How do we manage "distributed reputation" to sustain cooperation and detect and punish misbehavior?

Detecting and Preventing Malicious Behavior

- Cooperation needs consent of all participating nodes
- Cooperative Strategies can be jeopardized by malicious nodes
  - A malicious node may decide not to cooperate even when cooperation is beneficial for the nodes
- Need distributed mechanism for consent and reward management [Deb, Medard, Choute]

Methodology and Plan

Step 1: Use Game theoretic models to understand competition and limits of performance in non cooperative schemes

Step 2: Incorporate cognitive radio capabilities like – interference measurement, operating in different modes such as spread spectrum, OFDM etc, in game theoretic models

Step 3: Develop cooperative models using ideas from distributed control and optimization