Title

Cognitive Radio Networks as Sensor Networks

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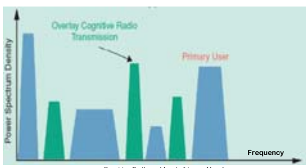
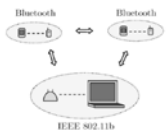
Introduction: Cognitive Radio (CR) Networks

The Need For Cognitive Radio Networks

- Radio frequency spectrum is an expensive and scarce resource.
- There are immense variations in usage of licensed frequency bands ranging from 15% to 85% (temporally and geographically) in bands below 3 GHz. Meanwhile, the unlicensed bands (like ISM bands) are becoming more crowded so that the problem of coexistence of heterogeneous systems is becoming increasingly important.



Cognitive Radio problem in Licensed bands



Cognitive Radio problem in unlicensed bands

What Is Cognitive Radio

- **Definition**

  Cognitive radio is a model for wireless communication where nodes adapt their transmission or reception parameters to communicate efficiently without interfering with high priority users, and coexists well with others.

  Cognitive radio system is aware of, learns and adapts to variations in its interference environment.

- **Primary Objectives**
  - Efficient utilization of the radio spectrum:
    - Achieve highly reliable communication in licensed bands without affecting licensed users, by using adaptive communications.
    - Efficient coexistence with heterogeneous networks in unlicensed bands.

Problem Description: Sensing Interference Characteristics Reliably in CR Networks

Interference Characteristics

- **The following information about the interference environment needs to be found reliably:**
  - Detection of primary users
  - Detection/identification of other interferers
  - Power spectral density of interferers
  - Statistics of interference over time
  - Location and velocity of primary users and interferers

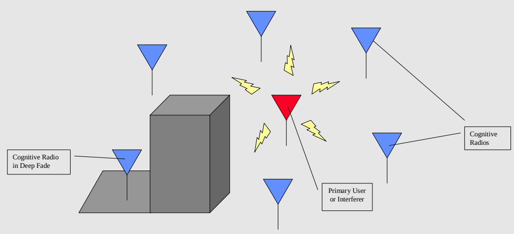
Challenges

- **A radio could be in deep fade, making it impossible to sense the channel reliably.**

  A radio in deep fade could start transmission when primary users are active, causing interference.

- **Optimum sensing algorithm changes in different channel conditions.**

  Under varying channel and interference conditions, resources available to sensing interference change, e.g. power and bandwidth allocated to control channel.



Proposed Solution: Adaptive Cooperative Sensing Algorithm For CR Networks

- ***Cooperative sensing*** among radios in a cognitive radio network results in more reliable sensing of the interference environment. Cooperation increases the probability of detection/identification and the accuracy of localization.
- Additionally, given resources available to sensing and cooperation between radios at each time, an ***adaptive algorithm*** optimizes performance by choosing amongst various cooperative sensing methods. Many of these problems have been addressed in other contexts in sensor networks, providing a good base for research.

For *detection* of interferers, the adaptive algorithm chooses from the following methods:

- In each radio, interference detection is performed using one of the following methods:
  - Pilot detection (when pilot is known).
  - Energy detection (when no information is known about interference).
  - Other known features of the source.
- The final result is combined using classical data fusion techniques, chosen according to knowledge of prior probabilities, bandwidth available in the control channel, and desired performance
- Coverage questions are very similar to such problems in source detection, with detailed differences in channel and source characteristics

For *localization* of interferers, the adaptive algorithm chooses from the following methods:

- Maximum likelihood estimate of location is used, assuming the cognitive radios know their own coordinates. The number of detectors involved is similar to source localization problems. Different channels however require different localization methods:
  - In Rayleigh channels: interference strength.
  - In Rician channels: interference strength and angle of arrival.