Throughput Enhancing Cooperative Spectrum Sensing for Cognitive Radios

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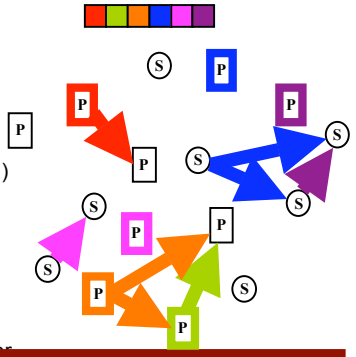
❖ The radio spectrum is a **scarce** resource.

- ➢ The demand for spectrum will continue to grow.
- ➢ Current spectrum allocation is regulated and licensed by FCC.
- ➢ Surprisingly, much of the licensed spectrum is **underutilized**.



❖ **Cognitive radios:** **s**econdary (cognitive) users opportunistically use the spectrum unused by **p**rimary (licensed) users.

- ➢ More flexible and efficient way of spectrum use.

❖ The general cognitive wireless networks

- ➢ A number of primary users communicate with their destinations via directly or in a cooperative fashion.
- ➢ A number of secondary users seek to access the unused spectrum by sensing the activity of the primary user.

Objective: Design a spectrum sensing scheme for **Enhancing the throughput** of the secondary users while **limiting the interference** to the primary users

Cooperative Spectrum Sensing

❖ Access scheme for the secondary users

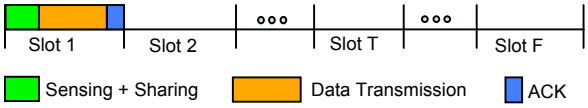
- ➢ Time-slotted communication.
- ➢ In each slot, secondary users pick a frequency channel randomly.
- ➢ The secondary users sense the picked channel and make a decision.
  - ✓ Energy detector is used for spectrum sensing.
- ➢ If the decision is “busy”, each user marks it in the frequency table.
- ➢ If the decision is “idle”, each user transmits its information over the channel.

❖ **Non-cooperative spectrum sensing**

- ➢ The information of the marked channel is **not shared**.

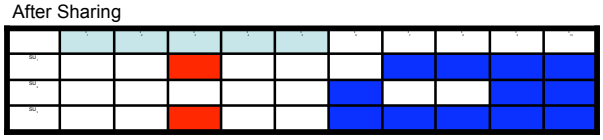
❖ **Cooperative Spectrum Sensing**

- ➢ The information of the marked channel is **shared**.
- ➢ Sharing the information using simple binary XOR operation.
- ➢ Sharing is done via a common time-slotted report channel.
- ➢ More complete occupancy information of the overall channels.
  - ✓ **Limit** the interference to the primary users.
  - ✓ **Increase** the possibility of choosing idle channels.



Before Sharing

After Sharing



SU_i: i^{th} secondary user

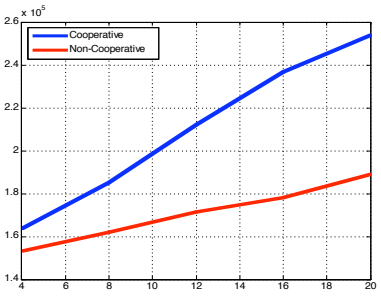
Bad Identifies “idle” channel as “busy”.

Good Identifies “busy” channel as “busy”.

Performance of Cooperative Spectrum Sensing

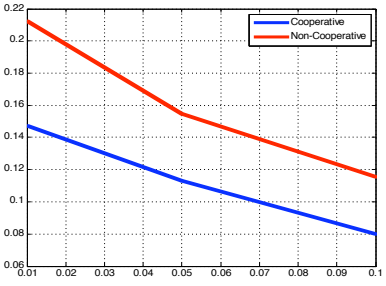
❖ Assumptions

- ➢ Channel state (either busy or idle) does not change during T slots and changes Independently after T.
  - ✓ Each secondary user refreshes its frequency table every T slot.
- ➢ Total number of channels = 14, Total number of secondary users = 5.
- ➢ Total number of busy channel = 10.
- ➢ P_d (prob. of detection) = {0.8 0.85 0.9}.
- ➢ P_f (prob. of false-alarm) = {0.01 0.05 0.1}.
- ➢ Any secondary user causing interference to the primary users receives penalty: bans its transmission for 6 time slots.
- ➢ Data transmission rate of the secondary user = 1Mbps.
- ➢ The number of packets transmitted/slot = 20.
- ➢ Report channel transmission rate = 0.25Mbps.
  - ➢ Size of report channel = 10 slots.
    - ✓ Overhead time for cooperative sensing = 4*10*4μs = 160μs.



➢ Throughput of the secondary user is **enhanced** by the cooperative sensing.

➢ The enhancement becomes more **apparent** as T increases.



➢ The interference to the primary user is **reduced** by the cooperative sensing.

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