Cognitive Radio Allocation Schemes: A Performance Comparison

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[1]Some work on Cognitive Radio Allocation Schemes was done in collaboration with Pawel A. Dmochowski (VUW) and Mansoor Shafi (TNZ).

Why CRs?

- Perceived shortage of radio frequency spectrum.
- Currently have *inefficient* use of spectrum. There are unused times, frequencies and spaces.
- CRs are being proposed as a solution to this problem.
- However, the primary (licensed) users should ideally remain ignorant of their presence.
- This simple constraint results in a lot of problems to be solved!

1 Introduction
- Introduction to Cognitive Radios (CRs)
- Overview of Results Obtained

2 Allocation of CRs
- Radio Environment Map (REM) and Primary Exclusion Zone (PEZ) Based Schemes
- Results

3 Conclusions

A bird's eye view of our research activities

Information theoretic analysis of CR networks

- Determine quantities like maximum allowable data rates.
- Determine the scenarios that are predominantly going to dictate the rates of CR networks in real environments.

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Level crossing analysis of cumulative CR interference

- How does the interference cross a particular threshold?
- And how long does it remains above or below it?
- Very important from the point of view of practical deployment.

A bird's eye view of our research activities

Multiple Input Multiple Output (MIMO) CRs

- Can the benefits of MIMO be achieved for CR networks? Still a big question.
- In fact the current version of IEEE 802.22 does not support MIMO CRs.
- Our research suggests that MIMO antenna selection is a plausible option.
- We are exploring MIMO CR network possibilities.

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CR interference and allocation issues

- Characterization of the aggregate CR interference?
- How should the CRs be allocated in the presence of primary users? The remaining talk focuses on this issue.

PEZ based CR allocation

- This scheme is based on geographical separation between the CRs and the licensed user.
- An exclusion zone of radius R_e is created around the primary user receiver.
- No CR is allowed to transmit inside the primary exclusion zone.
- The radius R_e is determined so that the SINR within the primary user coverage area is degraded by a certain amount.
- Specifically, the primary coverage area is calculated to give an SNR greater than 5 dB 95% of time.
- Then by allowing CRs to operate, R_e is determined so that a new SINR target (less than 5 dB) is achieved at least 95% of time.

REM based CR allocation

- Exploits small coverage areas available for reliable CR communication. Possible due to local conditions and shadowing.
- Assume the interfering CR signals are known apriori to the central CR controller.
- Then select the CRs that satisfy the SINR constraint.
- The constraint chosen is that the added interference must not degrade the SNR by more than Δ dB. For example, if SNR $=$ 10 dB in the absence of CRs, then the chosen CRs must give SINR $\geq (10 - \Delta)$ dB.

REM based CR allocation algorithms

Centralized Selection

- The instantaneously known interfering CR signals are sorted in ascending order by the CR controller.
- Based on the ordered list first n CRs are selected such that the combined interference due to these is less than or equal to Δ dB.

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Decentralized Selection

- Here the CRs are taken in their original order of arrival.
- Each interferer is considered in turn and is accepted if the combined interference from previously accepted CRs and the current CR is less than Δ dB.
- If a CR is not accepted, the next CR in the list is investigated.

Comparison between REM and PEZ schemes

Parameters assumed are: Primary user coverage area radius, $R = 1000$ m, high density of CRs $= 10,000$ CRs per sq. km, moderate density $= 1000$ CRs per sq. km., path loss exponent γ and shadow fading variance σ shown on figures.

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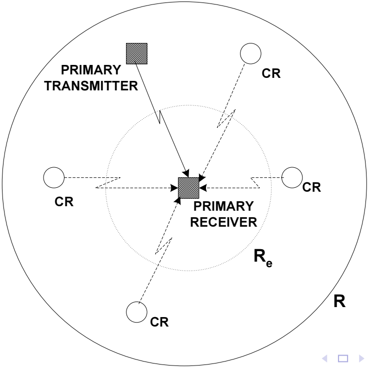

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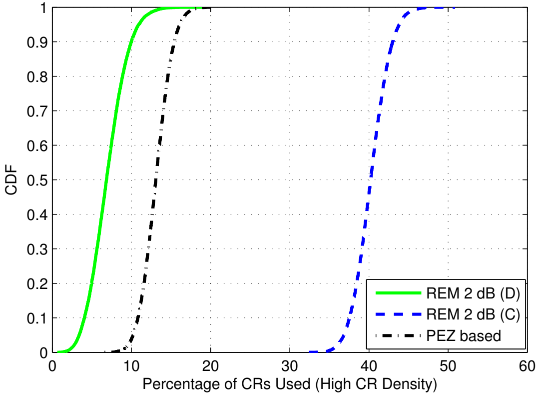

What if we do not have a perfect REM?

- We have also dealt with this problem.
- Obviously the results will depend on two things, namely:
    1. The grid size of the coarse REM
    2. The decorrelation distance of the shadowed signals
- The results are again pretty encouraging and suggest that for practical values of decorrelation distances reasonable grid size would be needed.

Final Comments

- Two interference management approaches have been considered based on REM and PEZ ideas.
- The REM approach requires considerable higher overheads but can perform substantially better than the PEZ approach.
- To achieve substantial gains an intelligent allocation method is essential.
- A REM scheme based on coarse information presents a bright picture.

Thanks

Thank you for your attention!