Lecture 5: Channel Assignment Algorithms in CRNs

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Spectrum Assignment

- After sensing, each SU selects the best spectrum bands from the detected spectrum holes according to their needs and QoS requirements.
- Multiple SUs might access the same spectrum band, which results in a collision (contention).
- We need to coordinate spectrum access among multiple SUs to minimize collisions, and increase cognitive system throughput.
- When a PU becomes active, the SU must change its operating band to avoid interfering with the PU.
- Spectrum allocation can be centralized, cluster-based or distributed.

Performance Optimization Criteria

- Optimizing radio resource allocation in CRNs attempts to:
- Improve utilization of sensed spectrum (**throughput** maximization).
- Achieve **fair** allocation of spectrum among multiple SUs.
- Meeting Quality-of-Service (**QoS**) requirements.
- Maximizing **energy efficiency** to extend battery life of secondary nodes.
- Accounting for **priority** among nodes.
- Avoiding **interference** to PUs.
- Reduction of spectrum **hand-offs**.

Radio Resource Allocation

- **Centralized scheme**: a central node is responsible for spectrum allocation decisions and power control among SUs.
- Initially, the spectrum is detected and the opportunities are identified by the centralized node on the basis of spectrum detection information provided by the SUs.
- In the second phase, resource allocation decisions are made according to some predefined performance optimization objective(s).
- The decisions are then communicated to SUs using a network-wide common control channel (CCC).

Advantages

- Decision at the central node has a global view of the whole network.
- So, centralized scheme can easily achieve optimization objectives, such as:
  - Throughput maximization: allocating more resources to SUs with good quality channels.
  - Minimizing SU collisions by proper coordination.
  - Ensuring spectrum sharing fairness among SUs.
  - Accounting for data and node priority, etc.
- All the above objectives cannot be achieved simultaneously, but we can achieve better results for one objective or a feasible combination of two or more criteria.

Disadvantages

- Central node needs significant processing power.
- Single point-of-failure.
- Requires the presence of a CCC (difficult to setup and maintain).
- High signaling overhead.
- The central node needs to broadcast radio resource allocation decisions to all SUs over the CCC. If SUs are spread over a large geographical area, large amount of power is required to ensure successful reception of control decisions at all SUs.

Distributed Resource Allocation

- No central entity. Each SU makes its band selection decisions in an autonomous manner or by cooperating with the neighboring nodes.
- Distributed resource allocation classes:

1. **Cooperative** distributed resource management: SUs exchange information (cooperate with each other) before making their own local resource allocation decisions.
2. **Non-cooperative** distributed resource management: SUs make their local decisions in a selfish manner without taking into account the impact of these decisions on the other SUs.

Distributed Advantages

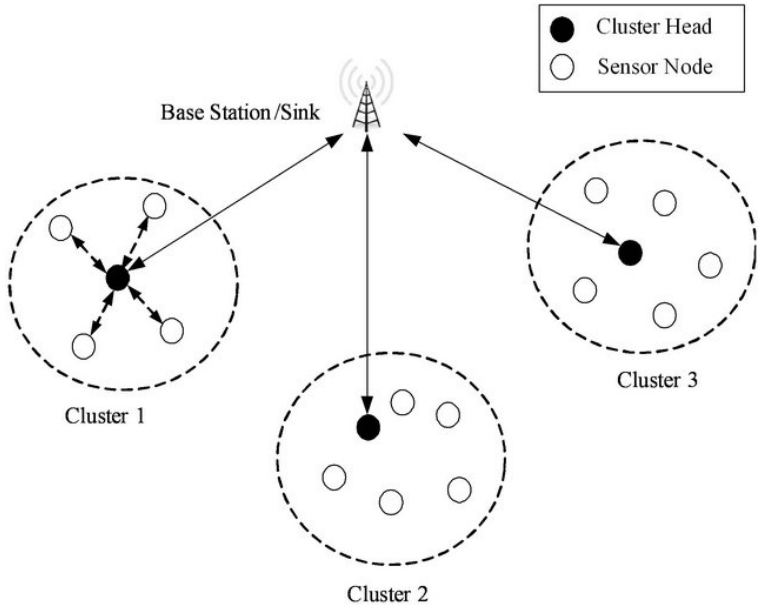
- SUs can quickly adapt to time varying wireless environment.
- SUs affected by PU activation can update their transmission strategies without waiting for the central node.
- If information exchange is among a small number of neighboring SUs, the signaling overhead is reduced.
- Non-cooperative schemes have zero signaling overhead (no need for a CCC).

Distributed Disadvantages

- Nodes make decisions based on local information (or information provided by neighboring nodes), which renders resource allocation non-optimal *globally*.
- Local sensing is sometimes unreliable, which can lead to inappropriate resource allocation.
- Difficult to achieve network-wide fairness (even with neighbor coordination).
- In cases of high traffic load, collisions can increase dramatically.

Cluster-Based Resource Allocation

- Hybrid between centralized and distributed schemes.
- The network is divided into small clusters, each comprising of several closely spaced SUs called cluster members.
- Each cluster has a Cluster Head (CH).
- Spectrum sensing inside the cluster is communicated to the CH, who performs resource allocation, and then communicates the decisions to the cluster members via a local CCC.



Advantages/Disadvantages

- Power required for the CCC in each cluster is significantly lower compared to the centralized scheme.
- In case of CH failure, the cluster members can subscribe to the nearest cluster or re-elect a new CH.
- Due to the small number of cluster members in each cluster, the signaling overhead is lower compared to the centralized case.
- But now we need a CCC, one per cluster.

