Weekly Report (2011-02-14)

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During the past two weeks, we have been surveying papers on routing and resource allocation in cognitive radio networks or related scenarios. We have listed the papers under the "Cognitive Radio" directory on our internal website. Based on the literature study, we make the following categorization and figure out possible solutions for our paper.

- **Coordination**: We are not sure whether "Coordination" is accurate here. In cognitive radio networks, secondary users should execute neighbor discovery, topology formation, path selection, resource allocation, and possibly collision avoidance, synchronization and so on. All these operations require the exchange of information, which is encapsulated in control messages. So a common channel should exist between two nodes for information exchange. This is the most fundamental problem in cognitive radio networks. All existing literature conduct the coordination in cognitive radio networks with one or both of the following assumptions:
  - *Common Control Channel*: A unlicensed channel is utilized as a common control channel while the licensed channels are for data traffics. Each secondary device is equipped with at least two radios: one is working on the common control channel while the rest is (are) transmitting or receiving the data traffics on licensed channels. With this assumption, control messages are passed through the common control channel.

    The drawback of this assumption is the requirement of a unlicensed channel shared by the whole network and at least two radios on each secondary device.
  - *Centralized Authority*: The secondary users depend on a centralized authority, possibly the base station, to pass control messages. In some papers, the joint routing and resource allocation problem is even solved in centralized manner.

    The drawback of this assumption is obvious: no distributed solution. However, IEEE802.22 protocol has a similar regulation.

  One recent paper, which was reviewed by Hongxing and accepted by INFOCOM'11, provides an alternative way to establish connection between any node pairs on a common data channel without the common control channel or centralized authority. It can guarantee that two nodes can meet on one common channel after a number of "jump-stay" operations but possibly with long delay.
- **Routing**: Current works mainly solve the routing problem by either centralized optimization or distributed DV-style algorithms. However, it is not desirable to design another centralized solution and the distance vector may not be accurate in cognitive radio networks as a consequence of the network dynamics.

The back-pressure (or so called "maximum differential backlog") mechanism is proved to achieve the maximum throughput in stochastic networks. However, as stated previously, the back-pressure mechanism may not perform well with light or medium traffic load since it tries out all possible paths and may route the packets through very long paths. One recent paper addresses on this problem with the joint consideration of shortest path and back-pressure metrics in INFOCOM'09. However, it is assumed that each link has the same capacity, *e.g.* one data packet in each time slot. In cognitive radio networks, the link capacity varies over time and location, as a result of the dynamic behavior of primary users and channel state. So a more sophisticated metric, which can actually reflect the underlying heterogenous link capacity, should be designed, *e.g.* ETX (Expected Transmission Count) proposed in MOBICOM'03.

- **Resource allocation**: The most important issue in resource allocation is the interference model. In current literature, only protocol interference model is assumed. The interference is minimized or the collision is avoided by either centralized optimization or distributed coordination with full information of neighbors.

  Some papers, not in cognitive radio networks, proposed randomized link scheduling algorithms in the CSMA manner. Collision-free transmission can be guaranteed with probability analysis. We can extend this solution into cognitive radio networks with multiple available channels.