Cooperative Routing Protocol in Cognitive Radio Enviornment

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ABSTRACT

Routing is the main research issue in the development of Wireless Networks. Many of the routing approaches have been borrowed from Mobile Ad hoc Networks (MANETs) to achieve routing solutions in Wireless Networks but are not ideal or optimal and do not utilize the characteristics of Wireless Networks to fulfil their benefits. Moreover, these approaches don't take into account the cognitive radio environment. Cooperative routing is discussed in this environment which takes maximum utilization of cognitive environment which is an on demand routing protocol.

I .INTRODUCTION

Cognitive Radio Network is intelligent networks that adapt to changes in their environments to make a better use of the radio spectrum. CR has been considered in Mobile Ad Hoc Networks (MANETs), which enable wireless devices to dynamically establish networks without necessarily using a fixed infrastructure. The changing spectrum environment and the importance of protecting the transmission of the licensed users of the spectrum mainly differentiate classical MANETs from CR-MANETs. The.Cooperative routing is on-demand based routing. When a source node has data for a destination node, it broadcasts a RREQ (route request) on the CCC (common control channel). Each intermediate node receiving a RREQ can calculate the accumulated cost from the source to itself .The accumulated cost is then placed into RREQ. Through rebroadcasted the RREQ by intermediate nodes, many RREQs finally reach destination. Destination will choose the path which has the minimum end-to-end path cost and then reply a RREP to source which will lead to saving of energy

II. FUNCTIONS OF COGNITIVE RADIO

Main functions of cognitive radio are:

1) Spectrum sensing: Detecting unused spectrum and sharing it, without harmful interference to other users. Detecting primary users is the most efficient way to detect empty spectrum.

2) Transmitter detection: Cognitive radios must have the capability to determine if a signal from a primary transmitter is locally present in a certain spectrum. Cooperative detection: Refers to spectrum-sensing methods where information from multiple cognitive-radio users is incorporated for primary-user detection

3) Power Control: Power control is used for both opportunistic spectrum access and spectrum sharing CR systems for finding the cut-off level in SNR supporting the channel allocation and imposing interference power constraints for the primary user's protection respectively.

4) Spectrum management: Capturing the best available spectrum to meet user communication requirements, while not creating undue interference to other (primary) users. Cognitive radios should decide on the best spectrum band to meet quality of service requirements.

III. COOPERATIVE ROUTING

Cooperative routing is on-demand based routing. When a source node has data for a destination node, it broadcasts a RREQ on the CCC. Each intermediate node receiving a RREQ can calculate the accumulated cost from the source to itself .The accumulated cost is then placed into RREQ. Through rebroadcasted the RREQ by intermediate nodes, many RREQs finally reach destination. Destination will choose the path which has the minimum end-to-end path cost and then reply a RREP to source which will lead to saving of energy

IV. SYSTEM ASSUMPTION

Consider a cooperative CR ad-hoc network that primary users are located in different regions and have different spectrum utilizations of their own spectrums. The same group of primary users act in the same primary users region, and operate at the same spectrum or channel. Secondary users are non-infrastructure based and spread over all these regions. The available channels are assumed to be organized in two separate channels. A CCC is used by all secondary users for spectrum access negotiations. The data channels are used for data communications. The data channels consist of a set of discrete mini-bands identified by a discrete index. Each user that has packets to send will contend the spectrum access on the fixed CCC. Assume that a CR user only has one transceiver to operate in either CCC or data channel at the same time. For example, there are three regions of primary users in labelled as PU1, PU2 and PU3. Assume there are three available data channels. Thus, the available channel set of a CR user located at PU1 may be {2, 3} when it detect the existence of primary users at channel 1. When two nodes want to communicate with each other, they should select a common available channel in both available channel set. Therefore, each source can build a suitable path to destination with different selected channels at each hop, and can find some relay nodes to do cooperative transmission among the path if possible.

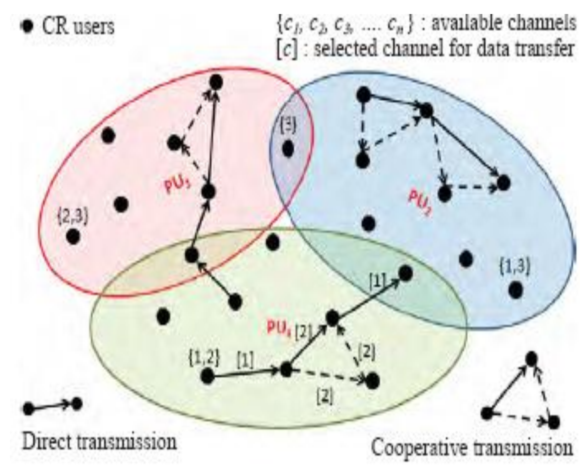


Fig.1 A cooperative CR ad-hoc network

In cooperative routing protocol, time is divided into *k* frames. Each frame consists of control phase and data transmission phase. Secondary users operate at CCC in control phase, and operate at data channel in data transmission phase. In control phase, there is a spectrum sensing process executed at physical layer to scan all spectrums, so secondary users can obtain the available channel set and active information of primary users periodically. Each secondary user can broadcast its updated information to neighbors during the information exchange period. If any secondary user has data packet to send, they can send out some negotiation messages in order to communicate with a specific receiver at a designed channel in data transmission frame.

In data transmission phase, CR users can adopt either direct communications or CC to forwarding packet. Fig.2 is a simple three-node network for CC. In time slot *t* as shown in Fig.2, source *s* sends a packet to destination *d*, which is also overheard by relay *r*. In the second time slot *t*+1 as shown in Fig.2, relay node *r* forwards the data received in the time slot *t* to destination *d*. Destination *d* can now apply any diversity combining technique [on the two copies of the data from two different paths, thereby achieving higher capacity gains.

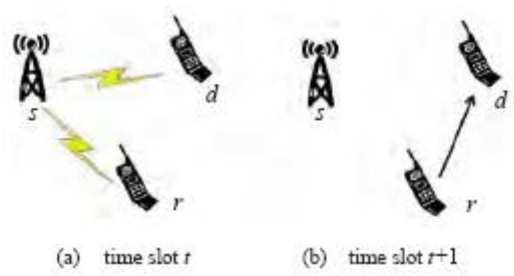


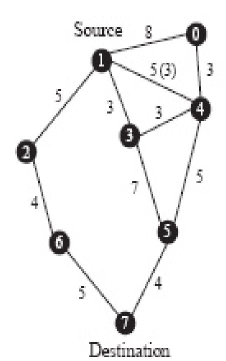
Fig.2 cc in the three node network

V. ROUTE DISCOVERY IN COOPERATIVE ROUTING

On-demand routing protocol including route request phase and route reply phase is described in detail. In route request phase, a source node *s* broadcasts a route request packet (RREQ) on the CCC in order to find an end-to-end minimum cost path to destination *d*. Each RREQ packet includes the cumulated path cost from source to the current receiving node. the spectrum and cooperative aware cost between any two nodes *i* and j can be defined as:

Cost i,j=1/C*ij (1)

Where C*ij is the maximal achievable capacity between node *i* and *j*. With such cost, if two nodes have more transmission opportunities, better channel quality, or cooperative benefit, smaller transmission cost between the two nodes is possible. A node *j* receiving a RREQ from node *i* will setup reverse path in its routing table and rebroadcast the RREQ. The fields of reverse path include the source *id* of RREQ, *id* of node *i*, cost cumulated from source to node *j* through node *i*, the selected data channel and selected relay node if CC is used. Through the reverse path, the RREP packet can route backward to the source along the end-to-end minimum cost path. Any intermediate node receiving more than one RREQ from the same source node *s* will update its reverse path and rebroadcast the RREQ when the cumulated path cost of current received RREQ is smaller than the one at its routing table. If any intermediate node has a fresh enough path to destination in its routing table, the node will generate a RREP and send it to source immediately. This can reduce the latency of finding a path from source to destination. In addition, in route request phase, RREQ is rebroadcasted only when node finds the other path with lower cost, the RREQ flooding overhead is mitigated. Destination node *d* will set a timeout period when it receives the first arrival RREQ from the same RREQ source. There may be several RREQs finally arriving at the destination node *d* along different paths within this timeout period. Destination *d* can simply choose the one with the minimum path cost. After timeout period, a RREP is sent back from destination to the source along the reverse path. The main intention of replying RREP is to confirm the channels or relay nodes which are used at the routing path from source to destination. Thus, a node *i* receiving a RREP packet from node *j* can confirm the next hop to route to destination and the corresponding channel and relay node for data communication with node *j*. For example in Fig. 3, we assume that destination node 7 replies a minimum cost path to source node 1 through intermediate nodes 5 and 4. The numbers nearby edges are the minimum transmission cost between two nodes. And the number inside bracket is the minimum transmission cost with cooperative benefit. Note that, the minimum cost from source node to intermediate node 4 is through relay node 3 as shown in node 4's routing table



Node 4 routing table

Dst.	Previous node	Cost	Ch.	Relay node	Relay Ch.
1	1	3	1	3	2

Node 5 routing table

Dst.	Previous node	Cost	Ch.	Relay node	Relay Ch.
1	4	8	1	-	-

Node 7 routing table

Dst	Previous node	Cost	Ch.	Relay node	Relay Ch.
1	5	12	1	-	-

An example for routing from source to destination.

VI. COOPERATIVE ROUTING ALGORITHM

Step1: Initially, source node s broadcasts a RREQ at CCC.
Step2: When Any node j receiving a RREQ with cumulated cost <s,i> from node i do
Step3: Node j finds the common datachannel c* that maximizes the capacity of using direct transmission at link (i, j).
Step4: Node j finds the common data channel c' that maximizes the capacity of using cooperative transmission via relay node r.
Step5: Node j calculates the achievable capacity between node i and j with relay node r.
Step6: For multiple candidate relay, selecting the one r* has the maximum achievable capacity
Step7: Node j calculates the cumulated cost<s, j> = cost i, j + cumulated cost<s, i>.
Step8: **If** the cumulated cost is smaller than the one in the routing table do
Step9: update node j's routing table
Step10: **If** node j is an intermediate node **do**
Step11: rebroadcasts RREQ with the cumulated cost<s, j>
Step12: **End if**
Step13: **If** node j is a destination **do** waits a timeout period and replies a RREP to the source node along the reverse path.
Step14: End when

CONCLUSION

Cooperative routing protocol in CR ad-hoc networks that addresses the concern of end-to-end CR performance over multiple hops .An on-demand based routing style which is more suitable in CRNs to find the end-to-end minimum cost path is used. First define the channel utilization, and then the potential bandwidth for a link at a specific channel. Through combining the potential bandwidth and the channel quality, the capacity of direct transmission or cooperative transmission at a specific channel with relay can be calculated. Then finally the relay availability indicates how often the relay can help for transmission. With these performance metrics, the maximum achievable capacity with cooperative benefit between two adjacent nodes can be calculated and evaluate the cost we used in routing discovery. Therefore, by using this CC technology, we can go one step further to leverage the available recourses in CRNs so as to improve their performance and also minimize the energy required for transmission.

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