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# A REVIEW ON DELAY-MINIMIZED ROUTING PROTOCOL IN MOBILE COGNITIVE AD HOC NETWORKS

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## Abstract:

Mobile Cognitive Ad Hoc Networks is the one of the cognitive radio networks which is the advanced networking technologies for spectrum scarcity problem constrain in the Federal Communication Commission (FCC). The cognitive radio networks are the CNs which abject its network parameters with respect to network environment. In cognitive radio network two users are the primary and secondary or cognitive users will access the available spectrum to communicate with users, when the spectrum is utilizing by the primary user the secondary user have to leave the spectrum and access the spectrum when spectrum holes are available for transmission. For this reason routing is required issue in cognitive networks and it is very challenging in mobile cognitive networks due to the mobility of the nodes, primary user interface and spectrum scarcity. In this paper some routing protocols based on mobile ad hoc cognitive networks and a review on the delay-Minimized routing protocols is presented.

*Keywords* —Cognitive Network (CN) Cognitive Radio Networks (CRN), Primary Users (PU), Cognitive User (CU), Ad Hoc Networks.

## I. INTRODUCTION

Cognitive Radio Networks (CRN) is the new technology used to overcome the spectrum scarcity problem in current wireless networks by Federal Communication Commission (FCC). In cognitive radio network is a network which have primary and secondary users which access the network based on Dynamic Spectrum Access (DSA). The primary user is the licensed user and secondary user is unlicensed user when the licensed user is accessing the spectrum the unlicensed user are not allowed so the secondary user has to sense the spectrum periodically to find the presence of primary user, presence of primary user is in dynamic in nature so the spectrum holes created by primary user is also dynamic, To over this the Cognitive user prefer the DSA. While using the DSA, routing is the challenging over cognitive radio networks.

### A. Categorization of Cognitive radio networks

Cognitive Radio Networks (CRN) is of infra-structured and infrastructure less, in infra-structured network it has a fixed structure like base station primary users secondary users and so on, in infra-structured network it has no fixed structure.

Centralized and Decentralized networks the Centralized networks are the network in which has base station in the central and primary users are present. Decentralized networks are the network which has no centralized base station and has the secondary users to communicate and primary users are present.

Static and dynamic networks the static networks the position of base station, primary users and secondary users are fixed but in the dynamic (Ad-Hoc) the position on primary users and secondary user will change (Mobility is nature).

### B. Routing in Cognitive radio networks

Routing in Cognitive radio networks is based on available spectrum and knowledge of spectrum to nodes in the network. Routing solutions for the Cognitive radio networks is of two types one is Full Spectrum Knowledge routing and second is Local Spectrum Knowledge routing.

Local Spectrum Knowledge routing has Minimum Power Routing, Minimum Delay-based Routing, Maximum Throughput-based Routing, Geographic Routing and Class-based Routing.

This paper is organized in the following manner section 2 Routing protocols in CRN, section 3 is Routing protocols of Mobile Cognitive Radio Ad-hoc Networks, section 4 is Delay-Minimized Routing protocols of Mobile Cognitive Radio Ad-hoc Networks, and section 5 is Conclusion and Future Works.

## II. ROUTING PROTOCOLS IN COGNITIVE RADIO NETWORKS

### A. Spectrum-Aware Routing (SPEAR)

Spectrum-Aware Routing (SPEAR) is a on demand and link based protocol support end-to-end throughput by integration of flow-based and link-based approaches, it used RREQ for route discovery by control channels it takes decisions with collaboration of PHY and MAC layers it handle mobility issues with Timeout field in periodic channel reservations messages. It takes the best path by maximum throughput, minimum hop count and link quality it has a communication overhead by route setup and route tear down.

### B. Spectrum-Aware Mesh Routing (SAMER)

Spectrum-Aware Mesh Routing (SAMER) is a link state routing protocol with minimum hop count and spectrum availability it gives end-to-end thought with the path with high spectrum availability, long-term stability and short-term opportunistic utilization of spectrum. The routing decisions are taken by PHY and MAC layers.

### C. Spectrum-Aware On-Demand Routing Protocol (SORP)

Spectrum-Aware On-Demand Routing Protocol (SORP) is an AODV protocol with control channel which uses the path delay and node delay (switching and back off delay) for path selection. In route discovery phase RREQ message is broadcast with a SOP append in the packet the control channel exchange the routing protocol messages and it gives end-to-end thought put SORP doesn't have link failure handling mechanism.

### D. Multi-hop Signal-transceiver Cognitive Radio Network Routing Protocol (MSCRP)

Multi-hop Signal-transceiver Cognitive Radio Network Routing Protocol (MSCRP) is an AODV protocol with on control channel. It is a spectrum aware routing and leaves/ joins messages of the nodes so it has the communication overhead of RREQ. In route discovery phase all nodes append their sate information and available channels set. Routing decision is taken with the collaboration of MAC, Physical and Network Layers.

### E. Reactive source-based routing Protocol

Routing in Opportunistic Cognitive Radio Networks is an on demand graph structured network protocol which uses the routing metric based on the probabilistic definition of available capacity over channel it has no link failure handling capacity and it discovers the route by using OSPF, Dijkstra-link algorithm. By using this Dijkstra-link algorithm it gives end-to-end throughput

### F. Local Coordination Based Routing and Spectrum assignment in Multi-hop Cognitive Radio Networks

Local Coordination Based Routing and Spectrum assignment in Multi-hop Cognitive Radio Networks is a modified version of AODV which is on demand routing protocol it has full mesh topology which uses channel scanning and beacon broadcast for neighbour discovery with control channel used for load balancing in routing. The route discovery is done by using RREQ and route decision is based on MAC and Network Layer. It has link failure handling capability which gives less end-to-end delay and performance.

### G. Multipath Routing and Spectrum Access (MRSA)

Multipath Routing and Spectrum Access (MRSA) is Mesh routing protocol based on round robin fashion data striping with minimum hop count by route discovery with control channel, Broadcasting RREQ messages. The massages sent to nodes periodically it can handle path failures by sending RERR messages and it has a communication overhead based on multiple flows on single radio.

H. **Cognitive Tree-based Routing (CTBR)** Cognitive Tree-based Routing (CTBR) is the tree based routing protocol with centralized routing it broadcast the root announcement (RANN) message periodically with a packet and used cumulative metric for path selection. It selects the path based on local and global decision schemes. It does not have route recovery mechanism to handle link failures and it has a control bytes transmission overhead.

## III. ROUTING PROTOCOLS FOR MOBILE COGNITIVE RADIO AD-HOC NETWORKS

### A. Fault-Tolerant Cognitive Ad-Hoc Routing Protocol (FTCARP)

It is a fast and efficient routing protocol for route recovery in presence of path failures during data deliver. It uses different route recovery mechanisms for different path failures.

### B. Cognitive Destination Sequence Distance Vector (C-DSDV) Protocol

It is a table driven routing protocol. To optimize the system performance of multi-hop CR ad-hoc networks by using multichannel routing table are updated immediately when there is change in channels the techniques is that combines the routing and channel allocation. In route discover phase common control channel use to broadcast the route updating in the routing table in this protocol best path selection is based on sequence number. In C-DSDV channel switching is used to improve the system performances. If there are more primary users routing overhead will be increased

### C. Cognitive Ad-Hoc On-demand Distance Vector (C-AODV) Protocol

Cognitive Ad-Hoc On-demand Distance Vector (C-AODV) Protocol is based on AODV a wireless network protocol it is designed according to avoid primary users activates regains for routing formation and packet discovery. It gives the minimized route cost by forwarding packets through joint path and channel selection at each node it takes the advantage of availability of multiple channels to improve the overall performances.

### D. SER-Spectrum and Energy Aware Routing Protocol

SER is an on demand routing protocol which provide high throughput in multi-hop networks it selects energy efficient route and assign channels and timeslots for connection request. The communication segment assignment algorithm is used for balances traffic load among the CR users. In route discovery phase it broadcasts Route Request Messages to other nodes so it has routing overhead of RRE, RREP, RERR and ROP messages.

### E. GYMKHANA Protocol

GYMKHANA is an on demand routing protocol and enhanced version of AODV used the GYMKHANA algorithm using virtual graphs and evaluate the cost by using Laplacian matrix. It has a secondary user's self-interference overhead.

### F. UNITED NODE Protocol

UNITED NODE Protocol is a distributed and efficient based interference aware routing protocol. It incorporates the spectrum availability cost and interference metrics into the routing algorithm to find better routes between the nodes it repairs routes by using route preservation method. It provides adaptability to the environment and increases throughput and reduces data delivery latency.

## IV. DELAY-MINIMIZED ROUTING PROTOCOLS FOR MOBILE COGNITIVE RADIO AD-HOC NETWORKS}

### A. ROPCORN Protocol

ROPCORN Protocol is the on demand routing protocol which was designed for data transportation using link modeling and used to minimized delay for a set of users in network. It broadcast the packets in link with the low cast and no primary user is affects. ROPCORN is based on RACON protocol it uses buffers in the intermediate nodes and forwards the packets there is no overhead due to the use of spectrum availability and load estimation, the optimal route selection is based on spatial or temporal locality of link disconnection.

### B. SEARCH A Routing Protocol

It is the on demand routing protocol and enhanced version of AODV which is based on the geographic routing and follow the greedy forwarding and PU avoidance for joint channel-path optimization algorithm to find the best path. SEARCH undertakes both the path

and selection to avoid PU activity region and tries to maintain end-to-end latency it has routing overhead due to the RRE, RREP, RERR and ROP messages.

### C. Link Prediction-Based Adaptive Routing

Link Prediction-Based Adaptive Routing is based on link-availability prediction. The link –availability prediction considers primary user activity and user mobility. This routing reduces the energy consumption and gives least delay by enhances network performance. It works based on link prediction and topology control

### D. Joint Routing and Channel Assignment

Joint Routing and Channel Assignment (JRCA) approach based on delay prediction and a heuristic algorithm which used the collision probability and Link Stability Prediction. It is and on demand routing protocol which user AODV type of routing with heuristic values and can find out the path with minimal end-to-end (e2e) delay.

### E. Adaptive Delay Tolerant Routing Protocol (ADTRP)

The ADTRP algorithm finds a stable sequence of instances of the mobile graph and the communication topology of interest such that the number of transitions from one instance of the topology to another in the sequence is the global minimum. The algorithm uses the average lifetime of the mobile graphs in the stable sequence for communication topology and it is a generic for stable sequence of any communication topology it uses the heuristic topology for routing so it improved throughput, better packet delivery ratio, decreased packet drop and reduced delay.

### F. STOD-RP: A Spectrum-Tree Based On-Demand Routing Protocol

STOD-RP is an on demand routing protocol which was designed for reduces the control overhead and average end-t-end delay minimization and it is an extension of the original Ad-hoc On-demand Distance Vector (AODV) protocol which uses spectrum tree addresses, spectrum decision and route selection in an efficient way for this route matrix is used. Fast and efficient spectrum-adaptive route recovery method is used when path is damaged.

## V. CONCLUSIONS

Routing is challenging issues in cognitive networks and it is very challenging in mobile cognitive networks due to the node mobility primary user interface and spectrum scarcity, this paper conclude that every protocol is designed for overcome certain problem in networks one is for multiple problems and one is for single problem like improving performance, minimized end-to-end delay, overall throughput increasing and so on. There are more protocols or improved versions of protocols for increasing problems in networks. The future work on this paper is a new delay minimized routing protocol will be proposed and implemented in NS3.

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