Performance Analysis of Different Routing Protocols in Cognitive Radio Networks

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Abstract*— The cognitive radio (CR) can give a wide assortment of insightful practices. It can screen the range and select frequencies that limit impedance to existing PU correspondence activity. When doing so, it will depend on an arrangement of guidelines that characterize which frequencies might be considered, what waveforms might be utilized, what control levels might be utilized for transmission. This paper bargains fundamentally with MANET based steering conventions execution which enormously relies on upon accessibility and solidness of remote range and furthermore a vital parameter that ought not to be dismissed keeping in mind the end goal to acquire exact execution estimations of intellectual radio network. The essential objective of any CR organize directing convention is to address the difficulties of the progressively changing system topology and build up a proficient course between any two hubs with least steering burden and data transfer capacity consumption. Here, we assess the execution and correlation of AODV, DSR, DSDV and OLSR steering conventions on the premise of different parameters, for example, parcel conveyance proportion, throughput et cetera. At last, select the best performing convention for CRN systems in view of various parameters.

Keywords*—Routing Protocols; CRN; PDR; Throughput;

I. INTRODUCTION

Cognitive radio is AN intelligent communication tool that's aware of its setting. A cognitive radio network (CRN) permits US to determine communications among CR nodes/users. The network parameters are often adjusted in line with the amendment within the radio environment, topology, operative situation, or user necessities. Main objectives of the CR network are:- efficient use of frequency spectrum and to attain the highly reliable and efficient wireless communications.

Cognitive radios will change their parameter like frequency, coding techniques, modulation techniques, power etc. per changing communication setting therefore leading to efficient utilization of accessible resources [12]. Cognitive radio networks consist of 2 styles of users, primary and secondary cognitive users. Accredited users have higher priority for the usage of the licensed spectrum [11]. On the reverse hand, unauthorized users must opportunistically communicate in authorized spectrum by dynamic their parameters in associate degree accommodative suggests that once spectrum holes environment offered as shown in fig.1

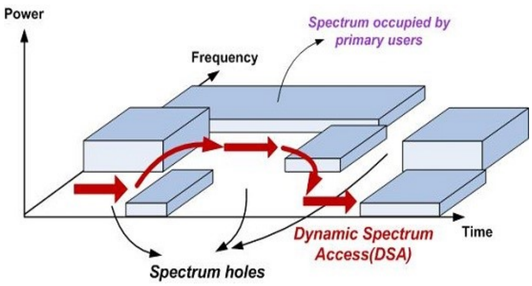

Fig 1. Spectrum Hole

Cognitive radio-based on sharing has primarily two major flavors, that is, horizontal spectrum sharing and vertical spectrum sharing. In the former case, all CR users have equal restrictive status, and in the latter case all CR users don't have equal regulative standing. There are a unit licensed users and unlicensed users in vertical spectrum sharing that dynamically use the spectrum without affecting the primary user's performances. Horizontal spectrum sharing will be between similar networks or between heterogeneous frequencies primarily based networks. Once all the heterogeneous networks having adaptive capabilities then it's cited as symmetric sharing. While, once there's one or additional network while not these cognitive/adaptive capabilities, this is often cited as asymmetric spectrum sharing.

II. RELATED WORK

Recent paper work is based on distributed CR routing protocols are as follow:

Rafiza Ruslan, Rizauddin Saian, Nurhamizah Mohd.Teramizi in [1]- As cognitive Radio (CR) has the potential to identify the unused spectrum so as to permit Cr users to use it without any interference with the primary users (PUs). Routing may be a important task in cr network (CRN) due to diversity in available channels. in this paper, they used Ad-Hoc On-Demand Distance Vector (AODV) and Weight cumulative Expected transmission time (WCETT) routing protocols for the economical route choice between the source and destination in CRAHN. The performance of AODV and WCETT are evaluated on the idea of average throughput in 3 different kind of routing structures to satisfy different requirements from users: i) single radio multi-channels, ii) equal number of radios and channels and iii) multi-radios multi-channels.

Their simulation result shows AODV has a efficient average throughput in single radio multi-channels whereas WCETT has a efficient average throughput in equal variety of radios and channels as well as in multi-radios multi-channels.

[2] Matteo Cesana, Francesca Cuomo, Eylem Ekici in [8] their working concept is based on CRN network. They mainly focused on the problems related to the design and maintenance of routes in multiple hop CRNs, clearly highlight their strengths and disadvantages. In a nutshell, the main challenges for routing information throughout multihop CRNs include: spectrum-awareness, setup of quality" routes and route maintenance has been considered.

[3] S. Selvakanmani and M. Sumathi, in [5] - They gave overview of various routing protocols for adhoc networks based on Multiple channel usage, Link Modelling, Geographic routing, Spectrum awareness, and Connectivity. They also showed classification of mobile cognitive radio adhoc network as Infrastructure CR (Primary/licensed) and Infrastructure less CR (secondary/unlicensed)

[4] Hang Su and Xi Zhang in [10] -They have proposed the cross-layer based opportunistic multi-channel medium access control (MAC) protocols, which includes the sensing of spectrum at physical (PHY) layer with the scheduling of packet at MAC layer. In their proposed protocols, every secondary user is equipped with 2 transceivers. initial transceiver is tuned to the dedicated control channel, whereas the second is intended specifically as a cognitive radio that may periodically sense and use the identified un-used channels. To get the channel state precisely, they proposed 2 community channel range detecting arrangements, specifically; the transaction based detecting strategy and irregular detecting approach, to help the MAC conventions for distinguishing the supply of remaining channels.

Ms. Shubhangini, R. P. Deshmukh and A. N. Thakare [5] have evaluated the special features of cognitive radio networks using the AODV & DSDV routing protocol for CRAHNs as in the wireless communication & propose new routing metrics, including transmission delay. Routing protocols for network without infrastructures have been developed. They need capability to determine how messages can be forwarded, from a source node to a destination node in the mobile nodes of the network. They also discuss regarding the packet transmission over variety of nodes and the next hope packet forwarding from supply to destination.

III. CLASSIFICATION OF ROUTING PROTOCOLS

In fact routing protocol make a decision and organized a path to transmit packets between computing devices in a CR mobile ad hoc network. In ad hoc networks, nodes aren't familiar with the topology of their networks. Instead, nodes have to discover it: usually, any new node announces its presence and listens for announcements broadcast by its neighbors. Each node learns about others nearby and the way to reach them, and will announce that it can also reach them. Note that in a wide sense, mobile ad hoc protocols can also be used virtually for specific purpose. The following are some ad hoc network routing protocols that are also used for CR network:

A. Proactive or Table-driven routing protocols

In this, each node maintains one or more tables containing routing info to every different node in the network. This protocol should maintain up-to-date of routing information whenever the topology will change the routing protocol propagates this information and store in routing table. There are different routing protocols have different method by which the topology change information is distributed across the network and store that information with routing-related tables. In this paper we consider OLSR and DSDV.

a) Optimized Link State Routing Protocol (OLSR)

OLSR is a proactive connection state directing set of rules, and utilizations hello and topology control (TC) messages to discover and afterward communicate interface state information all through the portable spontaneous system. Singular hubs utilize this topology information to figure next jump goals for all hubs at interims the system exploitation most brief bounce sending ways that. exploitation hi messages the OLSR convention at every hub finds 2-bounce neighbor information and plays out a disseminated decision of a gathering of multipoint relays (MPRs). Hubs select MPRs such there exists a way to everything about 2-jump neighbors by means of a hub hand-picked as partner degree MPR. These MPR hubs then supply and forward TC messages that contain the MPR selectors. This Being a proactive convention, courses to any or all goals among the system are outstanding and kept up before utilize. Having the courses out there at interims the quality routing table will be useful for some frameworks and system applications as there is no route disclosure delay related with finding an inventive course

b) Destination Sequenced Distance Vector (DSDV)

Every hub keeps up a table that contains the shortest separation and the primary hub on the shortest way to each other hub in the system. It fuses table updates with expanding arrangement number labels to anticipate circles. The tables are exchanged between neighbors at customary interims to stay up with the latest view of the system topology. Table updates are started by a goal with another grouping number which is constantly more noteworthy than the past one. The end hub of the broken connection starts a table refresh message with the broken connection's weight appointed to boundlessness (∞) and with a grouping number more noteworthy than the put away arrangement number for that goal. Every hub after getting a refresh with weight ∞, rapidly spreads it to its neighbors keeping in mind the end goal to engender the broken-connect data to the entire system. A hub consistently relegates an odd number to the connection break refresh to separate it from the even grouping number produced by the destination.

B. *On-Demand Routing Protocols*

As opposed to table-driven directing conventions all up and coming routes aren't kept up at every hub, rather the routes are made as and when required. once a source needs to send to a destination, it order the route discovery instruments to look out the way to the destination. The route stays legitimate until the goal is open or until the route is did not require anymore.

a) *Ad-hoc On-Demand Distance vector (AODV)*

AODV is an on demand routing protocol with small delay. That means that routes are only established when needed to reduce traffic overhead. It supports Unicast, Broadcast and Multicast without any further protocols. The Count-To-Infinity and loop problem is solved with sequence numbers and the registration of the costs. In AODV every hop has the constant cost of one. The routes age very quickly in order to accommodate the movement of the mobile nodes. Link breakages can locally be repaired very efficiently. [18]

Unicast Routing: For unicast routing three control messages are used: RREQ (Route Reply), RREP (Route Reply), RERR (Route Error). If a node wants to send a packet to a node for which no route is available it broadcasts a RREQ to find one. A RREP includes a unique identifier, the destination IP address and sequence number, the source IP address and sequence number as well as a hop count initialized with zero and some flags.

If a node receives a RREQ which it does not have seen before it sets up a reverse route to the sender. If it doesn't know a route to the destination it rebroadcasts the refreshed RREQ particularly enlarging the hop number . If it knows a route to the destination it creates a RREP.

Multicast Routing: One of the great advantages of AODV is its integrated multicast routing. In a multicast routing table the IP address and the sequence number of the group are stored. To join a multicast group a node has to send an RREQ to the group address with the join flag set. Any node in the multicast tree which receives the RREQ can answer with a RREP.

b) *Dynamic Source Routing (DSR)*

Expected to limit the transmission capacity consume by control packet in adhoc remote systems by dispensing with the table refresh messages. The essential approach here is to establish a route by flooding Route Request packets within the network Destination node responds by sending a RouteReply packet back to the source each RouteRequest carries a sequence number generated by the source node and the path it has traversed A node checks the sequence number on the packet before forwarding it The packet is forwarded only if it is not a duplicate RouteRequest The sequence number on the packet is used to prevent loop formations and to avoid multiple transmissions thus, all nodes except the destination forward a RouteRequest packet throughout the route construction phase

This protocol uses a route cache that stores all possible information extracted from the supply route contained in a data packet throughout network partitions, the affected nodes initiate RouteRequest packets DSR also allows piggy-backing of a data packet on the RouteRequest As an area of optimizations, if the intermediate nodes are also allowed to originate RouteReply packets, then a source node may receive multiple replies from intermediate nodes The supply node selects the most recent and best route and uses that for sending information packets each data packet carries the complete path to its destination If a link breaks, supply node again initiates the route discovery process.

IV. PROPOSED WORK

The proposed work describes the performance of routing protocol with the spectrum choice, route discovery and route maintenance in Network layer considering various numbers of nodes for the cognitive ad-hoc networks. the subsequent are considered as our Performance Metrics using which comparison of routing protocols such as AODV, DSDV, DSR and OLSR has been performed:-

A. *Packet delivery ratio:-*

It is defined as the ratio of data packets received by the destinations to those generated by the sources; it can be numerically defined as: PDR= Σ (Data packets received by the each destination) / Σ (Data packets generated by the each source)

B. *Throughput:-*

It is defined as the total number of packets delivered successfully over the total simulation time. The throughput is usually measured in bits per second (bits/sec).

Throughput= (total number of delivered packet * packet size) / Total duration of simulation

C. *End to end delay:-*

The time it takes data packet to reach the destination It incorporates all possible delay happen while buffering during route discovery latency, queuing at the interface queue. Delay metric is calculated by subtracting time at which first packet was transmitted by source from time at which last data packet arrived to destination

Avg EED= Σ time spent to deliver packets for each destination / Number of packets received by all destination nodes

D. Average Energy consumption:-

It is the ratio of sum of total energy consumed by each node to the total number of nodes .The energy consumption of the on-demand protocols increases as the maximum motion speed grows.

AEC = Σ (Initial Energy - Final Energy) / Total number of Nodes Residual Energy = Initial Energy – AEC

E. Normalized Routing Load:-

It is defined as the ratio of number of routing packets transmitted to data packet delivered at the destination. Each hop-wise transmission of a routing packet is considered as one transmission.

NRL = Routing Packet / Received Packets

V. SIMULATION RESULTS

Simulation is performed using Network Simulator-2 (NS-2) version 2.34, since it is open source free software in which various specifications can simply modified and changed. The network consists of Number of nodes placed randomly in a terrain 1000m*1000m with flat grid topology. For MAC layer protocol we have used the Distributed Coordination Function (DCF) of IEEE 802.11 as it captures link breakages effectively as well as IEEE 802.15.4 used for sensing network. TCP traffic is exchanged among the nodes with transport layer protocol being FTP. All the nodes in the simulation has omni-directional antenna. The simulation results are as follows:

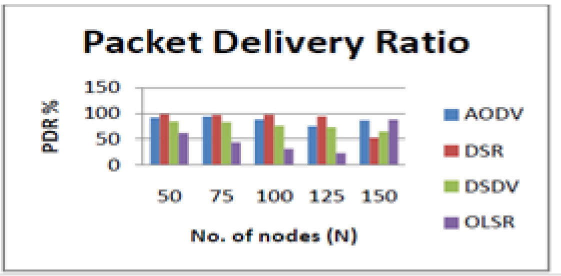

Fig 2. Packet Delivery Ratio

Fig 2. A simulation result shows that PDR for DSR protocol is highest among all protocols which are almost above 90% for all the nodes topology.

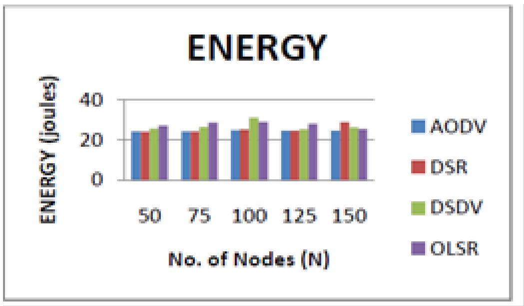

Fig 3. Energy

Other important parameter in any network is energy consumption which shows that how much energy is used during whole transmission process. This paper calculates the residual energy of nodes which is more in both DSDV and OLSR protocols for different traffic conditions

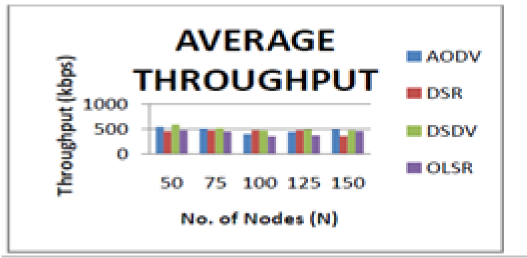

Fig 4. Average Throughput

Fig 4: Performance in case of average throughput, DSDV protocol is more efficient when less traffic is there but with increasing number of nodes it becomes equal to DSR protocol.

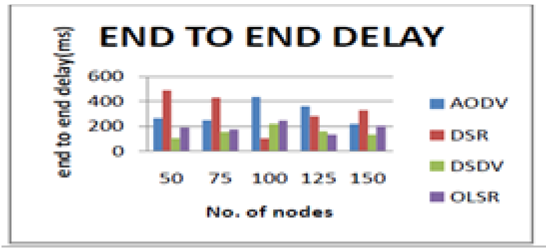

Fig 5. End to End Delay

Results in case of end to end delay, DSDV is having minimum value and it is best suited when heavy traffic is present in CR network.

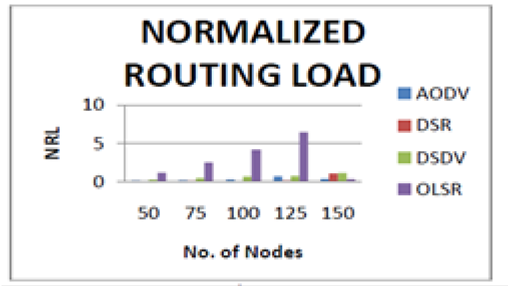

Fig 6. Normalized Routing Load

Fig 6: Another parameter used is normalized routing load which is lowest for DSR protocol and slightly more than DSR in case of AODV protocol. Both can be used for efficient CR transmission while required less routing overhead.

VI. CONCLUSION

The proposed research work presents extensive simulation analysis for four routing protocols under varied traffic scenarios for CRN. Routing protocols will be evaluated for the optimum performance on all chosen metrics i.e. PDR, End-to-End Delay, energy, throughput and authority. Performance is different for different protocols with respect to various metrics parameter. A future work can be considered by carrying out simulation to analyze and compare the performance of hybrid routing protocol with the routing protocols analyzed in this work where completely different scenarios could be inspected while introducing randomness to the packet size and rate.

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