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EMPIRICAL PERFORMANCE EVALUATION OF PUCRN AND CBRP-CRN PROTOCOL IN COGNITIVE RADIO AD-HOC MESH NETWORKS

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ABSTRACT

Now a day's Wireless communication plays an important role in many of the user applications. Many of these applications follow either unicast or multicast routing protocol for their communication. In wireless mesh networks multicast routing protocol is mostly adopted as we can send more data packets to multiple places at the same time. So it is more important to understand and evaluate routing protocols in wireless mesh networks as it provides more reliability, efficiency with less bandwidth than in any other networks. In this paper we have simulated, examined and analysed two important routing protocols namely Primary user in cognitive radio network (PUCRN) and cluster based routing protocol in cognitive radio network (CBRP-CRN) which are models of mesh based routing protocols in wireless mesh networks. To better evaluate these routing protocols we have made required changes in the fields like change in number of nodes, pause time, traffic pattern and other parameters. We have used performance metrics like end to end delay, throughput and packet delivery ratio to evaluate the performance of PUCRN and CBRP-CRN in cognitive radio wireless mesh networks. Our scope of work will help you to compare and evaluate these two routing protocols using NS2.

Keywords: *Wireless Mesh Networks, Routing protocol, CBRP-CRN, PUCRN*

1. INTRODUCTION

Cognitive radio is the promising and upcoming technology that provides solution for unlicensed users and helps for the better and efficient utilization of spectrum. A cognitive radio network gives the importance of intelligent and spectrum selection. Cognitive radio decides the transmission parameters such as modulation type, channel, transmission rate and channel depends on its circumstances this technology requires some kind of network that helps in proper functioning of its task.

Wireless mesh networks[5,14,15,16] operates for low cost and are widely used in local area networks, wide area networks and metropolitan area networks. Because of its features like community, high connectivity and neighbourhood home these mesh networks improves the performance of the network, so can be used for cognitive radio technology. It tries to improve load balancing, efficiency of protocol, failure model and throughput of the network with the help of its

Advanced features. Wireless mesh networks provides high performance when there is good configuration, easy deployment, fault tolerance and flexible network architecture. In mesh networks each mesh router acts as a serving point to all the clients. Mobile users, laptops, or workstations are the mesh clients in the network which shares data over the Internet. Mesh clients have their respective Mesh Routers to which they direct their traffic; from there they forward it to the backbone of the wireless mesh networks. Wireless mesh networks gives the assurance that community wide network can be accessed at reasonable cost. Having the additional wireless bandwidth in wireless mesh network is a beneficial. WMN's is used for the two types of wireless communications for both the user access and data transmission. Most of the mesh systems are construct to use unlicensed spectrum[2,4,7,8,12,13]. Peculiarly the 2.4 GHz band is allocated to the IEEE 802.11 devices; it is not only used by these devices but also by other devices such as remote controls,

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microwave ovens and cordless phones. For the intelligent wireless communication cognitive radio is the only concept which gives better results. Increasing resource demand for wireless networks is the main reason for the huge usage of cognitive radio. Wireless mesh networks helps in the development and implementation of the cognitive radio thus, WMN have benefit from the development of cognitive radio technology.

In most of the mesh based routing protocols each and every node forwards the packet to one of its parents and finally reaches the destination. So here we can observe these type of routing protocols follow a concept of group forwarding from the each node. Here some set of nodes form as a group and cooperate each other in the propagation of packet from source to destination. Also they maintain separate mesh for each kind of groups in the network and utilize the features of mesh based topology. Each node sends the packet arrived to it to several other nodes within the same group, same time in multiple paths. This feature makes this mesh based topology to provide more reliability and controls redundancy in the network. If they maintain multiple paths for sending the data overhead will be increased in the network, so such factors must be controlled and special measures must be taken care in the network. In our later sections we provide detailed description about PUCRN and CBRP-CRN routing protocols and provided simulation results that compares performance of these two routing protocols[6,10,17].

2. PUCRN PROTOCOL:

PUCRN (Primary user in cognitive radio networks) one of the mesh based routing protocol [16] in which the source multicasts the packet to the receiver where source need not to get any information about the location, nature of the multicast group, also it need not become part of the multicast group in order to send the packets or the data. In this protocol receiver follows receiver-initiated approach in order to join the group. It takes the help of core within the group to know or form the route without flooding the packet within the network. Messages are transmitted with the help of MAP (multicasting announcement packets). Each MAP contains group leader address, group address, sequence number, core distance, parent and mesh membership code. Sequence number often increases by one for each and every multicast announcement. The nodes collects the data from the announcement and from that information it elects the core of the group, forms a route and maintains the required information with the help of collective lists and use them whenever required

2.1 Leader Election

Generally a core election takes place whenever a new receiver joins the group. Firstly it checks whether the new receiver have received Multicast announcements or not, if it had received the announcements then it remains as a part of group and doesn’t participate in elections, if it had not received them then the receiver becomes leader of the group and perform its functionalities as a leader. It sends packets frequently to its neighbour nodes and to itself at a hop count of 0. Among all the received messages nodes only transmit the message having highest core ID to its neighbour nodes. So from this we can understand that any new receiver joining the group becomes core of the group and if more number of receivers joins the group simultaneously then the one with the highest ID becomes leader of the group.

2.2 Mesh Establishment And Maintenance

Receivers play an important role in establishment of mesh. Receiver itself adds its parent to the network depending upon the measurement of link reliability. Depending on the selection of number of parents by nodes the redundancy increases in the mesh network and is controlled by accuracy in the network links. Receiver while announcing multicast packet need to set the parent field. The parent field setting depends on choosing number of parents by node to be included in the mesh. Also mesh membership code is set to 1 by receiver (Mesh member) before sending the multicast packet. If it is non mesh member or non-receiver the membership code is assigned to 0.

Connectivity list contains many neighbours and in that one of them can be a mesh child if they satisfy these conditions: (a) this field's announcement arrives within the time of arrival of two announcements layoff. (b) If the neighbour core's distance is greater than its own distance to the core. (c) Its ID must be greater than or equal to its parent field. (d) Code of mesh membership must be greater than 0. Condition 1 helps to know whether the neighbour is true or not. If there are more than one mesh child in their list then they can update mesh membership code by 2 and can become mesh member. Summarized membership codes are given below: 0 indicates that it is not a

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receiver, 1 indicates that it is not a mesh member but a receiver, 2 indicates that it is not a receiver but a mesh member, 3 indicates that it is both mesh member and a receiver.

2.3 Forwarding Multicast Data Packets

There are two stages of sending data packet from sender to the receiver. One is as non-member mesh can also send the packet, it slowly moves from source in direction of core. Once it reaches the mesh member it can be easily reached to destination. It can be done with the help of mesh members with a code 2.

While sending the packet, security is provided by means of encapsulating it within the unicast packet. Destination address is also provided for it and generally one of its parent node is set as the address and sometimes address is selected based on highest ID of the parent available to it. The intermediate nodes receiving the packet from the sender will do the same action as done above. In the same fashion the packet is sent to other nodes and slowly to the core in the same way. Once it gets near mesh member the packet is removed from the encapsulated packet and there by remaining tasks are done by the mesh members. For Example node 7 which is at a distance of 4 from the core encapsulates the multi packet within the unicast packet and addresses its parent node as node 8 and packet is forwarded to node 8. Now from node 8 the same process is repeated again. It again set the destination address to node 11. Now as the node 11 is the mesh member it removes the packet from the unicast packet and it makes the packet to be flooded in the mesh. Now the mesh members with the help of packet ID removes the redundant packets and uses them. As mentioned above in flooding the members with mesh membership code greater than or equal to 2 will be flooding the packet, there is no chance of flooding the packets by only receivers

3. CBRP-CRN PROTOCOL

Cluster Based routing protocol works based on the formation of clusters. The nodes within the network forms as cluster in the following manner: Whenever node enters a space where clusters are formed it will be in state of “undecided”. It conveys its presence to the head of the cluster by sending Hello message. Then the cluster head receives this message and immediately it sends back Hello message to the node which is in undecided state. Now after receiving this message the node treats itself as member in that cluster. If the message doesn’t reaches the node within the stipulated time then there are two cases: one is node treats itself as cluster head if it has directions in both ends to its neighbour. Other is node remains as it is in undecided state and repeats that process again and again.

Nodes in order to maintain the correct information from the neighbours, it keeps track of neighbour table. In this table the information about state (member or cluster-head) and link (bi or uni) is maintained for each neighbour. Similarly cluster-head also keeps track of information about its neighbour clusters in the adjacency table and also about its members. Cluster head helps its neighbour clusters to follow the route to reach its cluster head or its member.

If source wants to send packets to destination, the node or source sends route request packets to the cluster heads which are neighbour to them. Now the cluster heads checks whether the destination of the packet is a cluster member or not. If it is a cluster member then it automatically sends the packet directly to it. If not then it forwards the packet again to its neighbouring clusters heads. In the packet cluster head address is maintained for future reference. When the packet reaches the destination, it observes the route and send the same route with the help of record available in packets received. If the reply message doesn’t receive the source within the stipulated time the source then sends back request again by backing off exponentially.

4. PERFORMANCE EVALUATION

We usually consider three parameters here like Packet-delivery ratio, Throughput and end-to-end delay to evaluate the performance of the routing protocols in the simulator. Packet delivery ratio can be defined as ratio of packets arrived at the receiver side to the packets send by the source side. Throughput can be defined as average of all the packets arrived at the receiver end in metric of bytes per second. Average End-to-End Delay can be defined as delay made by the data packets in reaching the destination successfully. Many other delays like queuing, buffering and propagation delays which occurs during route discovery are included in this delay

5. SIMULATION SCENARIO

We use network simulator (NS-2) for evaluating

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routing protocol in various parameters. We use this by varying nodes ranging from 3 to 25 with different situations. As said in 3.10.1.1 we use Random Way Point model as a mobility model. This model helps to know the movement of nodes within the simulated area. The greatness of this model is that it gives emulation to the user that the nodes are moving as if it is moving in a real situation. The nodes selects a position in the area and move according to the maximum and the minimum speeds. With the help of pause time the nodes move from one position to other in the simulation area. Only after the pause time node moves from that position and the pause time is usually from 0 to 0.3 mts/sec and sometimes up to 10 mts/sec. Each node actually moves at a speed ranging from 0 to 15 m/sec randomly in varies directions in the network. Pause time indicates that node after reaching a specified point the node needs to stop at that location for that amount of time. Distributed coordination function available in IEEE 802.11 is treated as MAC layer protocol in wireless LANs. To send the packets we used radio range of 220 mts with a bandwidth of 1.5 to 2 Mbps. For the means of communication we have used CBR with a maximum interface queue length of 240. We have used Packet Delivery Ratio, Average End-to-End Delay and Throughput to evaluate the routing protocol.

6. SIMULATION RESULTS

We have compared and evaluated two routing protocols under the mesh topology namely PUCRN which is mainly originated by the receiver to join a multicast group and Cluster based routing protocols. These two routing protocols act like state of art in the Mesh networks. We have carried out several experiments by changing various parameters in various situations. For better comparison of these two routing protocol we have changed number of nodes with different scenarios, with different traffic. Also we have selected the mobility of the node ranging from 0 mts/sec to 10 mts/sec. whenever we change the number of nodes we have ensured that all other change in only small percentage, because by remaining same situations and varying the nodes gives better results. Mainly the traffic has been slightly changed when the numbers of nodes are changed to understand actual performance. Maintain same number of channels for all types of nodes gave us better results. So we get combination of 3 graphs with different combinations like one for throughput, one for packet delivery ratio and last is end-to-end delay. The performance results with graphs are illustrated in Figures 3.8 to 4.0 for all the parameters and issues considered. Simulation is carried out for 200.00 sec for each and every execution in the simulation area. Finally multiple executions are performed by changing the nodes, traffic in the network helped to better evaluate these two protocols.

The figure-1 shows that the throughput performance of PUCRN and CBRP routing Protocol. It is observed that PUCRN routing protocol performs much better than the cluster based routing protocol. The throughput of CBRP drops drastically when compared to PUCRN. This is mainly because of the way PUCRN routing protocol takes place, its way of joining the group, sending multicast packets effects the performance. Also PUCRN make use of only one control packet to solve the queries of receivers whereas cluster based uses more than one. Joining the group and way of sending the packet effected lot on throughput performance of CBRP routing protocol. PUCRN delivers larger throughput values as it mainly discusses on solving the redundancy in the mesh network. From the figure-2 it is observed that the packet delivery ration of PUCRN is better than Cluster based routing protocol. We can also see that there is small change in packet-delivery ratio even when number of nodes is changed. There is poor performance by the CBRP when compared to PUCRN because of more number of failures in some places by the CBRP. The figure-3 depicts the end-to-end delay of CBRP and PUCRN it is observed that the PUCRN performs better than CBRP and provides minimum end-to-end delay than CBRP. This happens because there are more number of confirmations given in CBRP. As in PUCRN it maintains more number of parents in the mesh it quickly forwards the packet as soon as it arrives to it and duplicate packets are eliminated with the help of cache ID. From the graph it is clear that the PUCRN displayed really consistent results than cluster based routing protocol in the mesh networks.

7. CONCLUSION

PUCRN routing protocol is exceptionally a state of art in mesh based type of routing protocols. Simulation results also proved that PUCRN is better than other routing protocol namely cluster based routing protocol in various performance metrics. The mechanism behaves exceptional when we change number of nodes, traffic, and mobility in the network. PUCRN performs better in packet delivery ratio when compared to CBRP. This

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quality in the routing helped the researchers to design more routing protocols of this kind which improves the performance of the network. Finally it's interesting to evaluate PUCRN in various situations in NS-2. PUCRN stood unbeatable in the evaluation of all types of performance metrics when compared to other routing protocol.

REFERENCES:

[1]. M. Cesana, F. Cuomob, and E. Ekicic, "Routing in cognitive radio networks: Challenges and solutions", Elsevier Ad Hoc Networks , vol. 9, no. 3, pp. 228–248, May 2011.
[2]. Babu, E. Suresh, C. Nagaraju, and MHM Krishna Prasad. "An Implementation and Performance Evaluation Study of AODV, MAODV, RAODV in Mobile Ad hoc Networks."
[3]. K. C. How, M. Ma, and Y. Qin, "Routing and QoS provisioning in cognitive radio networks", Elsevier Computer Networks , vol. 55, no. 1, p. 330342, January 2011.
[4]. M. Youssef, M. Ibrahim, M. Abdelatif, L. Chen, and A. V. Vasilakos, "Routing metrics of cognitive radio networks: a survey", IEEE Communications Surveys and Tutorials , 2013.
[5]. I. Pefkianakis, S. H. Wong, and S. Lu, "SAMER: Spectrum aware mesh routing in cognitive radio networks", in Proc. Of IEEE DySpan , 2008.
[6]. Babu, E. Suresh, C. Nagaraju, and MHM Krishna Prasad. "An Implementation Analysis and Evaluation Study of DSR with Inactive DoS Attack in Mobile Ad hoc Networks." International Journal of Engineering Innovations and Research 2.6 (2013): 501.
[7]. K. R. Chowdhury and I. F. Akyildiz, "CRP: A routing protocol for cognitive radio ad hoc networks", IEEE Journal on Selected Areas in Communication , vol. 29, no. 4, April 2011.
[8]. S. Cacciapuoti, M. Caleffi, and L. Paura, "Reactive routing for mobile cognitive radio ad hoc networks", Elsevier Ad Hoc Networks , vol. 10, no. 5, pp. 803–815, July 2012.
[9]. K. Chowdhury and M. Felice, "Search: A routing protocol for mobile cognitive radio ad-hoc networks", Elsevier Computer Communications , vol. 32, no. 18, pp. 1983–1997, December 2009.
[10]. Gopi, A. Peda, et al. "Designing an Adversarial Model Against Reactive and Proactive Routing Protocols in MANETS: A Comparative Performance Study." International Journal of Electrical and Computer Engineering (IJECE) 5.5 (2015).
[11]. G.-M. Zhu, I. F. Akyildiz, and G.-S. Kuo, "STOD-RP: A spectrum-tree based on-demand routing protocol for multi-hop cognitive radio networks", in Proc. of Globecom , 2008.
[12]. J. Broch, D. A. Maltz, D. B. Johnson, Y.-C. Hu, and J. Jetcheva, "A Performance Comparison of Multi-Hop Wireless Ad Hoc Network Routing Protocols", in Proc. of ACM MobiCom , October 1998.
[13]. S. R. Das, C. E. Perkins, and E. M. Royer, "Performance comparison of two on-demand routing protocols for ad hoc networks", in Proc. of IEEE INFOCOM , March 2000.
[14]. R. Draves, J. Padhye, and B. Zill, "Routing in multi-radio, multi-hop wireless mesh networks", in Proc. of ACM Mobi- Com , 2004.
[15]. F. Akyildiz, W.-Y. Lee, and K. R. Chowdhury, "CRAHNs: Cognitive radio ad hoc networks", Elsevier Ad Hoc Networks vol. 7, no. 5, pp. 810–836, July 2009.
[16]. Babu, E. Suresh, C. Nagaraju, and MHM Krishna Prasad. "A Comparative Study of Tree based Vs. Mesh based Multicast Routing Protocols in Mobile Ad hoc Networks." IJETICS November (2013).
[17]. Kumar, S. Ashok, et al. "An Empirical Critique of On-Demand Routing Protocols against Rushing Attack in MANET." International Journal of Electrical and Computer Engineering (IJECE) 5.5 (2015).

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Table 1: Simulation Environment

Simulator	NS -2.31
Total No: of Nodes	3,5,10,15,20,25
Simulation Time	200 sec
Simulation Area	1000 * 1000
Node placement	Random
Pause Time	0.2
Mobility Model	Random waypoint
Radio range	220 m
Channel Capacity	1.5 – 2 Mbps
MAC protocol	IEEE 802.11
Data packet size	24 bytes

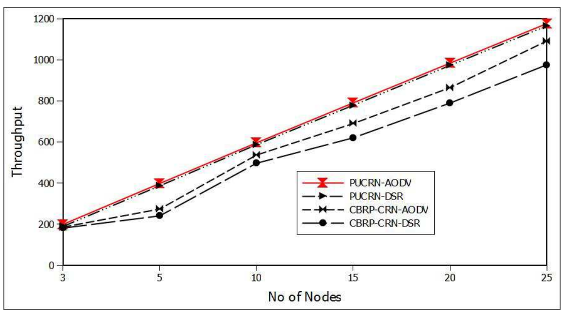

Figure-1: Throughput With Varying Number Of CBRP Vs. PUCRN

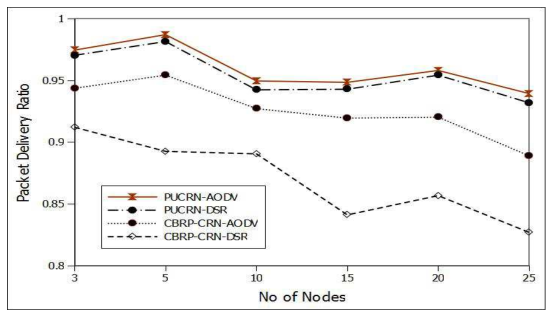

Figure-2: Packet Delivery Ratio With Nodes For Varying No Of Nodes For CBRP Vs. PUCRN

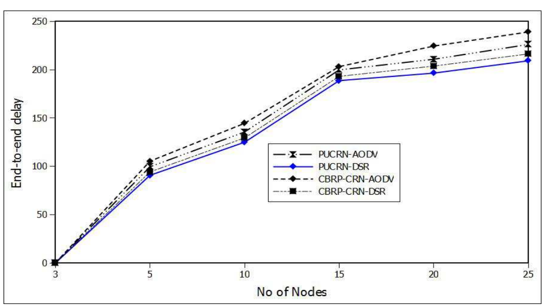

Figure- 3: End-To-End Delay With Varying No Of Nodes For CBRP Vs PUCRN