International Journal of Innovative Studies in Sciences and Engineering Technology (IJISSET)

ISSN 2455-4863 (Online) www.ijisset.org *Volume: 3 Issue: 10 | October 2017*

Cognitive Improved AODV Routing Protocol for Cognitive Radio Adhoc Network

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Abstract: *Cognitive Radio Network (CRN) introduced to solve the problem of spectrum scarcity by taking advantage of the unused spectrum. Cognitive Radio Adhoc Networks (CRAHNs) considered as one kind of different types of cognitive radio networks it operates without infrastructure and this lead to various challenge in data routing like frequent topology change, spectrum availability and intermittent connectivity caused by the Primary User (PU). . In this paper a new cognitive node model with a new routing protocol for (CRAHNs) referred as Cognitive Improved Adhoc hoc On Demand Distance Vector (CIAODV) has been proposed with an aim to eliminate the overhead, resource consumption and taking advantage of conventional (AODV) protocol which considered as the most suitable protocol to dynamic and infrastructure less networks. . The simulation results prove that the (CIAODV) protocol achieves better performance in the term of throughput, end to end delay and overhead as compared to (AODV) protocol.*

Keywords: *cognitive radio adhoc network (CRAHN), routing protocol, Cognitive Improved Adhoc hoc On Demand Distance Vector (CIAODV), cognitive node model*

1. INTRODUCTION

The main purpose of Cognitive radio technology is to improve the spectrum utility in the licensed frequencies and to improve the congestion in the 2.4GHz ISM band [1],. Recent research in this area has mainly focused on spectrum sensing, deciding the best possible spectrum for use, and allocating transmission schedules to the CR users [2]. Moreover, such architectures are generally single hop.

Cognitive Radio Ad-Hoc Network (CRAHNs) is a new developed technology of wireless communication [3]. The main difference between the new and traditional one is there is no infrastructure means the host and routers are the same so every node can be used as host and router at the same time.

Cognitive Radio Adhoc Networks (CRAHNs) considered as one kind of different types of cognitive radio networks fig (1), it operates without infrastructure and this lead to various challenge in data routing like delays fig(2), frequent topology change, spectrum availability and intermittent connectivity caused by the Primary User (PU)[4].

Cognitive radio technology(CRT) used cognitive mac which is designed for single-hop centralized Cognitive Radio networks under the roles of IEEE 802.22.due to the elimination, complicity and the updated researches is still infancy, an adaptive cross layer aware mac can be used instead of it [5].

The new cognitive radio node model has been deigned using omnet++ simulator with a frame work consisting of cognitive physical module and an intelligent data link module using crosslayer aware mac protocol.using omnet++ simulation tool basic and generic features (e.g., discrete event scheduling) and simple and easily reusable C/C code implementation. We have made this choice to ensure that this framework completely fits our purpose, that is, the establishment of a generic architecture to simulate transmission of data over cognitive radio adhoc network.

The new routing protocols in cognitive radio network can solve the challenges but they introduced various shortage like the resource consumption and route complicity procedure. In this paper a new node model with a cognitive capability, consisting of physical layer module that can be used for cognitive radio and special kind of multi-channel mac protocols known as smart mac which use cross layer routing knowledge has been proposed in addition to an improved AODV routing protocol for (CRAHNs) referred as Cognitive Improved Adhoc hoc On Demand Distance Vector (CIAODV) with an aim to eliminate the overhead, resource consumption and taking advantage of conventional (AODV) protocol.

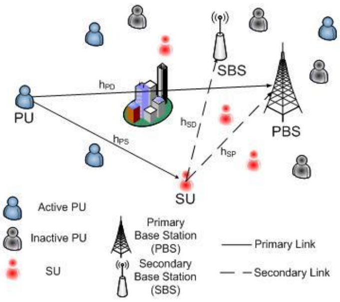

Fig 1: *cognitive radio adhoc network*

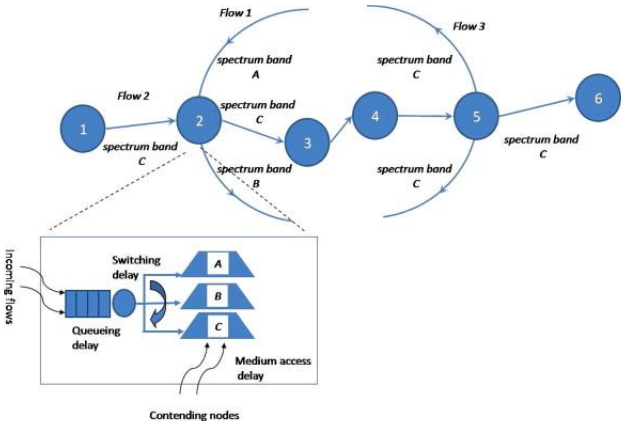

Fig 2: *Delays in cognitive radio routing*

2. RELATED WORK

There has been an active research in exploring routing protocols in cognitive radio networks. Here a brief discussion of the up-to-date research relevant to our work.

Ad hoc On-demand Distance Vector Routing (AODV) is algorithm for the operation of sensor networks. Each node operates as a specialized router and routes are obtained as needed i.e. on-demand with little or no reliance on periodic advertisements. The new routing algorithm is quite suitable for a dynamic self-starting network as required by users wishing to utilize sensor networks. AODV provides loop free routes even while repairing broken links. Because the protocol does not require global periodic routing advertisements, the demand on the overall bandwidth available to the mobile nodes is substantially less than in those protocols that do necessitate such advertisements. AODV can be called as a pure on-demand route acquisition system, in this nodes do not lie on active paths neither maintain any routing information nor participate in any periodic routing table exchanges. Further, a node does not have to discover and maintain a route to another node until it needs to communicate. To maintain the most recent routing information between nodes the concept of destination sequence numbering will be used. Each node maintains a monotonically increasing sequence number counter which is used to supersede stale cached routes [6].

In [7] they propose new routing metrics, including Routing for CRNs using IEEE 802.11 which are the official standards for wireless communication. Routing protocols, for network without infrastructures, have to be developed. These protocols determine how messages can be forwarded, from a source node to a destination node which is out of the range of the former, using other mobile nodes of the network. Routing, which includes for example maintenance and discovery of routes, is one of the very challenging areas in communication.

In [8] a protocol referred as Cognitive Improved Hierarchical on demand distance vector (CIH-AODV) has been presented. In this work the author built a protocol for mesh network.

In [9] a protocol referred as cognitive ad-hoc on-demand distance vector (CAODV) has been presented .In this work the author design a reactive routing protocol for the considered scenario able to achieve three goals: (i) to avoid interferences to primary users during both route formation and data forwarding; (ii) to perform a joint path and channel selection at each forwarder; (iii) to take advantage of the availability of multiple channels to improve the overall performance. Two different versions of the same protocol, referred to as Cognitive Ad-hoc On-demand Distance Vector (CAODV), are presented. The first version exploits inter-route spectrum diversity, while the second one exploits intraroute spectrum diversity.

3. SYSTEM MODEL

The architecture of our node model concentrate in designing a model with a cognitive capability, hence we used a physical module which has the ability of making spectrum sensing and detecting beside a mac layer with across layer behavior to take advantage of using multichannel in addition to stay under the IEEE 802.11 policy. The framework of the node model can be divided into three parts:

1. Physical module: (PHY layer)

The model of a wireless device always includes a physical module which actuates according to some defined physical models. This model includes one or more analog models and a designated decider. As shown in fig(3).

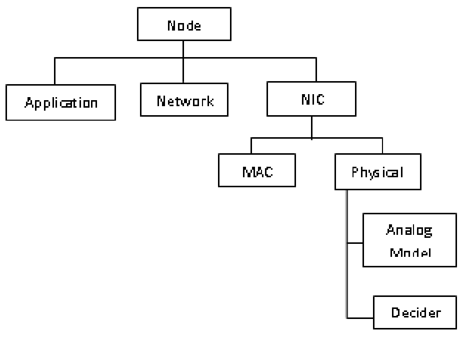

Fig 3: *Node model hierarchical*

A. Analogue models:

The analog models specify the way the attenuation which is suffered by a signal is calculated. If more than one analog model is defined, the final attenuation is the combined effect of all of them. The attenuation of a signal is calculated by implementations of shadowing, fading and path-loss models. Any arbitrary number of analogue models can be plugged into the physical layer. Each analogue model is basically a filter class for signals. Summed attenuation of all analogue models gives the attenuation part of all signals, which is calculated at the start of the reception of a message. Together with the sending power of a received packet the decider can later on calculate the SNR.

B. Decider

The decider aims at deciding if an incoming packet is to be received or not, i.e., passed to the upper layer (usually the MAC sub-layer). For instance, it can take the decision based on a SNR (Signal to Noise Ratio) threshold and on a defined bit error rate.

The Decider has three main tasks to do. First one, the decider has to classify and decided on incoming messages into receivable messages or noise. Second one, at the end of receiving a receivable message, the decider has to calculate the BER for the message. At last it has to provide information about the current state of the channel.

The physical layer is responsible for simulating the propagation and transmission delay of the message. The message is passed at least twice to the decider: at the start of message and at the end of the message. The decider can also request to get the message at arbitrary times in between. After the decider calculates the bit errors, the message has to be handed to the MAC layer. The physical layer stores all messages into a class called the Channel Info class. The Channel Info class acts as service provider that keeps track of all Air Frames on the channel. Channel Info provides a function that returns all Air Frames intersecting with a pre-determined time interval [10].

2. Cross layer aware MAC protocol: (Data link layer)

Channel access between SUs in a CRT requires a CRT based MAC protocol, which can coordinate the SUs through channel sensing, selection and access. While research in CRT MAC cognitive MAC is still in its infancy, multi-channel MAC extensions have been realized in IEEE 802.11 to enable all hosts to operate in multiple orthogonal channels simultaneously in order to improve network-wide throughput. This type of mac layer protocol for Cognitive Radio Technology is based on CLA (Cross Layer Aware) technology. In this different type of Mac protocol can be adapted by the system on basis different physical parameter, receiver power, SINR and minimum power to transmit for hop by hop packet transfer knowledge base. This smart mac protocol provided a frame work to observe and make decision to switch on between those candidate protocols. The switching between different MAC protocols will be validated and used in future by the system based on short term statistics [11].

3. The Cognitive Improved AODV (CIAODV) protocol. (Network layer)

The main design goal of (CIAODV) protocol is to improve the scalability of (AODV) protocol to be compatible and suitable for using in (CRAHNs) while keeping the metrics of it, we also minimizing the impact of mobile devices in the network by improving the RREQ message by using N of hop knowledge and mobile cost method.

Due to topological structure and variety of spectrum availability in (CRAHNs) this can lead to a link failure and start a new rout discovery when using (AODV) protocol hence the first development must be done in the rout discovery scheme.

The CIAODV has a function to minimize the link failure caused by the mobile node this has done by adjusting the hello message and the neighbor table updating files. The CIAODV protocol calculate the percentage move of devices if it is high the protocol decrease the hop count unless it increase the hop count in the case of static or fixed devices.

The algorithm used to find the route using the cost mobile method has been done as follows in the route discovery scheme.

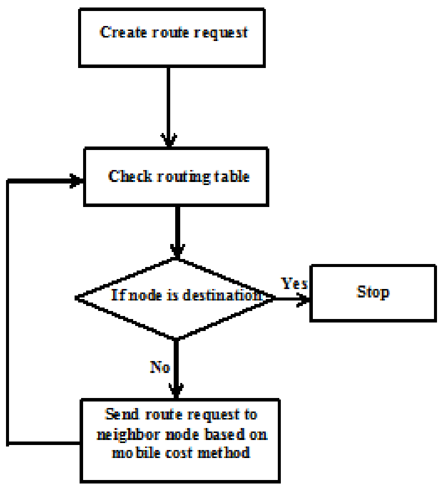

Figure 4: *modifications in route discovery*

1. The source node creates a route request.

2. Then check the routing table of the neighbor node.

3. If this neighbor node is the destination then stop the process.

4. If not the destination then calculate the mobile cost in the neighbor routing updating table.

The enhancement in the neighbor discovery has been done in the neighbor file and the hello message process using the cost mobile method in the knowledge of mobile balance of the network by increasing the number of static node and decrease the number of mobile node in the path by finding the path with the minimum number of mobile nodes.

This flow chart shows the modification in the neighbor and hello message process.

1- First check the neighbor table of the node.

2- If the hello message of the previous is a hello of static node then take next hop and increase the number of hop.

3- Unless the node is static neighbor that means its mobile node then compute the next hop interval by using the equation

Int hop= cost mobile (1)

Next hop= Int (1-α) – Int (α/2) (2)

When 0≤ α≤ 1

This step has been introduced to minimize the next hop interval in case of mobile node to increase the number of fixed node if available in another path, and decrease number of mobile nodes.

4- If the node is not static neighbor then check the IP address if it is not destination start a new neighbor route table check, if it is destination ENDS the process.

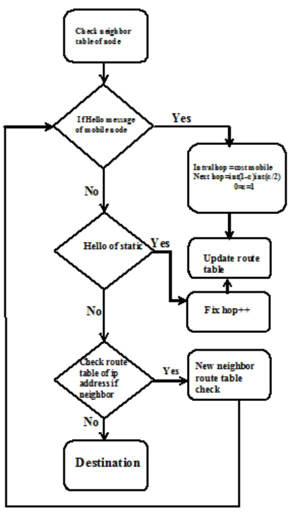

Figure 5: *modifications in neighbor updating file*

4. SIMULATION SETUP PARAMETERS

1. Simulation Tool (OMNET++)

Here we discussed the most important steps in creating the (CRAHNs) node using OMNET++ network simulator and the implementation of the (CIAODV) protocol in the network layer .OMNET++ was chosen as the developing platform, mainly due to its open source nature, its well organized modular architecture , the existing documentation and the provided IDE (Integrated Development Environment).

2. Set up parameter

3. Performance Evaluation

The performance evaluation of the (CIAODV) protocol is evaluated by comparing it with (AODV) protocol in the same condition.

In the simulation the traffic sources are Constant Bit Rate (CBR). The source-destination nodes are spread randomly with a random mobility model for the CU nodes. The spectrum divided into 9 channels each CU can use single channel while the PU can claim multiple channel. First we evaluate the CIAODV performance compared with traditional AODV protocol. Second we evaluate whether the protocol is suitable for cognitive radio network.

We evaluate four performance metrics:

C. Packet delivery ratio:

Is the ratio of the data packet delivered to the destination to those generated by the source.

$$PDR=\frac{\text{Total number of data packets successfully delivered}\times 100\%}{\text{Total number of data packet sent}}$$

End to end delay:

The average delay includes all possible delays.

End to end delay = S/N

Where *S* is the sum of the time spent to deliver packets for each destination, and *N* is the number of packets received by the all destination nodes.

D. Overhead:

Represents Total number of bytes and packets used for routing during the simulation.

E. Throughput:

Represents the average rate of successful packet delivery per unit time over a communication channel.

Throughput = ∑ Packet Size/ (Packet Arrival - Packet Start)

TABLE I

Set up parameter	value	Set up parameter	value
Area of simulation	2000x2000 sq. units	Routing algorithm	Optimal path
Number of CU	Varied from 4 to 20 step size 2	Packet transmission interval	4s
Number of PU	3	Channel available by PU	9
PU transmission range	250m	Mobility channel interval	5s
Mobility model	Random mass mobility	CU transmission range	120m
PU node mobility	Fixed	Routing protocol	CIAODV
Speed of CU	100 MPs	Simulation duration	500s

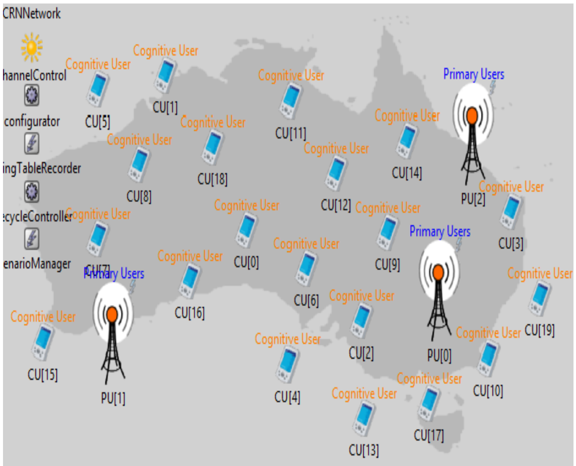

Fig 6: *Sample simulation environment with 20 nodes*

5. RESULT AND DISCUSSION

The simulation results are shown in the following section in the form of line graphs. The performance of CIAODV based on the varying the number of nodes is done on parameters like packet delivery fraction and average end-to-end delay and throughput.

Figure7 highlights the relative performance of CIAODV it delivers greater percentage of the original AODV protocol.it also give better performance when the number of cu increased unlike the AODV.

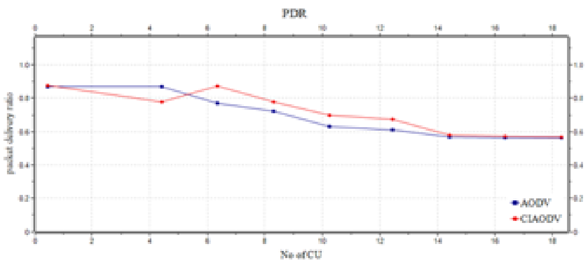

Figure 7: *packet delivery ratio vs number of cognitive user node*

Figure 8 shows the average end to end delay. CIAODV recorded less delays comparing to AODV but it is almost getting uniform due to increasing in no of cu.

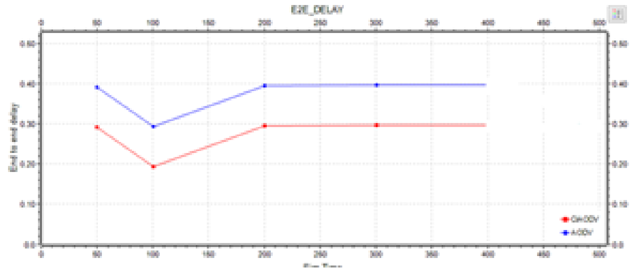

Figure 8: *Average End-to-End Delay (ms) Vs Number of cognitive user*

From figure 9 we can observe that CIAODV demonstrates significantly lower routing overhead than AODV. It is almost the consistent.

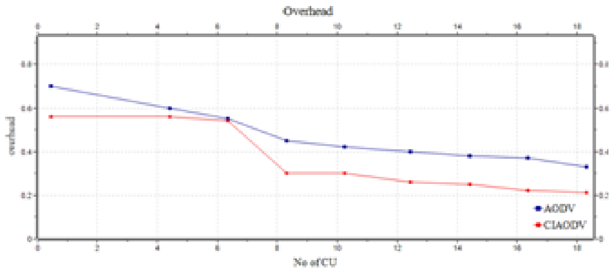

Figure 9: *overhead*

Figure 10 shows the impact of increasing simulation period on average throughput. We observe that, with the increased of number of cognitive node the throughput getting increased. The CIAODV record best performance than AODV at all.

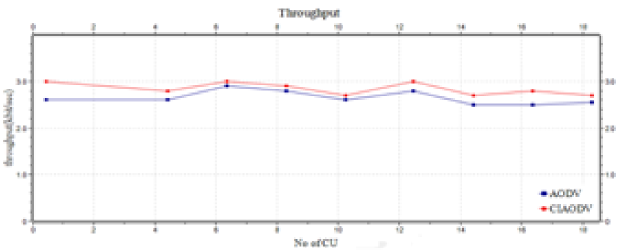

Figure 10: *Throughput Vs No of cu nodes*

6. CONCLUSION

In this paper, we proposed a new node model with a new routing algorithm CIAODV, which maintain nodes based on AODV for cognitive radio adhoc network. The new node model has a base of cognitive radio physical model and cross layer aware mac protocol to take advantage of multiple channels and a good connection between the cognitive interface and the adhoc network layer to improve the overall performance.

The proposed protocol enhances network performance by selecting the most stable node by choosing a path has minimum number of mobile node.

Simulation results indicate that we can use traditional ad-hoc routing protocols in a platform of cognitive radio network with suitable modification. Which mean making less of the resource consumption caused by the cognitive radio routing protocols. The result also shows that the modified protocol has better performance in the terms of throughput, average end-to-end Delay and overhead. Moreover the performance of protocol is satisfied under the environment of cognitive radio.

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