Introducing a new method of multiple routing using the AODV algorithm for cognitive radio networks

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ABSTRACT

Cognitive radio networks are introduced as an efficient method in facing the problem of improper use of frequency spectrum in wireless networks. The routing issue is one of the newest and most important titles of researches in cognitive radio networks with distributed architecture (ad-hoc cognitive radio networks). The nature of the multihop with distributed architecture is one of the main reasons for decline in spectrum efficiency and route capacity in wireless networks. Using the multichannel networks and sending the information through different channels is a more efficient way of confronting this problem. Paying attention to the existed features in this type of channel caused to introduce different routes and most important of them is AODV protocol. A new method is introduced in this article for improving the routing in AODV algorithm which is introduced by using the factors so that in order to find the best route from the beginning node to the destination node, the data traffic was studied and the best route was selected by considering the abovementioned factors. The results of the simulation show that the new algorithms in most cases are better than the classic algorithms of AODV.

INTRODUCTION

A cognitive radio network is a network without communication infrastructure the graph of which is always changing. These types of networks have two usages: a primary user collection which have the right to use a part of an allowed spectrum and a secondary user combination which can enter the allowed part without affecting the user’s performance and the dynamic of the users distinguishes the networks (Cesana, M., et al., 2011).

Today cognitive radio networks have comprehensive uses and provide services and so developed significantly. These networks are developing and the provided services are growing better and better each day. From architecture point of view the wireless networks are divided into two sections with infrastructure and without infrastructure (Cesana, M., et al., 2011). The general feature of these wireless in that they need calculation to reach the nodes and a network without infrastructures includes a lot of nodes without fixed station and wired connection for transforming the information and network management.

Mostly the topology of the mobile networks is composed of the nodes which dynamically and continuously enter or exit the network. No central control or fixed structure exists for supporting the body of the network and restructuring it (Che-aron, Z., et al., 2013). These networks general are a combination of same nodes which connect to each other centrally and wirelessly. Understanding and discovering the route have significant importance due to inconsistency of cognitive radio networks.

Various routing algorithms are suggested for these networks each of which has advantageous and disadvantageous. According to planning view, the routing protocols are two types of table driven (Proactive) and on-demand (reactive) (Che-aron, Z., et al., 2013). One of the most important routing algorithms suggested for radio cognitive networks is AODV algorithm by Perkins (Perkins, C.E., et al., 2000). This algorithm is on-demand and is one of the most efficient routing algorithms.

The way of routing is important for secondary users. We encounter a combination of frequency spectrum and opportunistic access to frequency spectrum. AODV algorithm is predicted for routing in multi routed. These algorithms have Distance vector nature and discover the route based on demand since calculating the routes which are changing is useless. AODV algorithm is just concerned with the distance factor and when the short routes are crowded, it has low efficiency.
Different article are written about improved routing and selecting the best route in AODV. For example (Royer, E. and C.E. Perkins, 1999) a multi route algorithm based on AODV is introduced to different groups through multicasting the PREQ message. In (Marina, M.K. and S.R. Das, 2001) a multi route algorithm is introduced based on AODV which discovers several routes between the beginning and destination node and finally selects the route which has the lowest hops. In (Khamforoosh, K., et al., 2008) a multi route algorithm on AODV is developed based on the distance of the nodes. In (Bettstetter, C. and C. Wagner) a new method of knowing the energy of the nodes for routing AODV is introduced to improve the life of the network.

In this study a new method is suggested for improving the AODV algorithm which not only changes the routing to multi route mode but also has the less hops and shortest distance.

Section 2 is a short review on classic AODV algorithm. Section 3 introduces the new suggested method and section 4 is the efficiency of the new algorithm and section 5 is conclusion.

**Knowing the classic AODV Protocol:**

AODV is a dynamic routing protocol on demand so that routing is done in need of new route. When the beginning node needs sending a package to a destination node, if there is no routing information then a discovery process through distributing the demand message of PREQ is done. As the message is received, each node creates a route back to the beginning node and then updates it and if the received node is not destination or does not have a new destination the PREQ package is distributed again, otherwise, a package of responding the route (PREP) is sent and updated. When the PREP finally reaches the beginning, the discovery period of the route is finished and the new route can be used for sending the data packages (Perkins, C.E., et al., 2003).

When a route same as destination is created, each node should use a number of links or layer mechanism of the network to keep the route. In other words, the common node tries to know that the next hop is toward the destination is available or not. Lack of continuance from a Hello message is considered as the fact that the link between the node and its neighbor is needed. Then a route error message (PERR) is created for informing the nodes. If the message passes the route, each node updates its routing table by invalidation of the route. Finally the broken routes are omitted.

The models of RREP and PREQ messages related to classic AODV algorithm are shown in figure 1 and 2.

**Fig. 1:** the model of PREQ message

<table>
<thead>
<tr>
<th>Number of jump</th>
<th>Application Number</th>
<th>Destination sequence numbers</th>
<th>Source sequence number</th>
<th>Address of the destination node</th>
<th>Address of the source node</th>
</tr>
</thead>
</table>

**Fig. 2:** Model of PREP message

<table>
<thead>
<tr>
<th>Number of jump from</th>
<th>Lifetime</th>
<th>Source sequence number</th>
<th>Address of the destination node</th>
<th>Address of the source node</th>
</tr>
</thead>
</table>

New records of the routing table of each node have also fields as shown in figure 2.

<table>
<thead>
<tr>
<th>Number jump to a destination</th>
<th>Stability of the routing</th>
<th>Lifetime</th>
<th>The next jump to the destination</th>
<th>Destination sequence numbers</th>
<th>Address of the source node</th>
</tr>
</thead>
</table>

**Suggested model:**

In classic AODV algorithm of each node omits the neighbors of the PREQ as it receives a PREQ message and this action causes the demand for new route by all the neighbors and finally leads to discovering the route through the mentioned node. In suggested method, if the PREQ messages reach the destination all of them are responded separately and none is omitted. Only the PREQs are omitted that are received form the same neighbor for that destination. This causes creating multiple routes between the beginning and destination node. So the new method acts for finding the multiple routes.

On the other hand, AODV algorithm is distributed comprehensively in the network and after discovering the new route, it is compared based on numbering and hops and the route with biggest number and less hops as the best route and updates in the routing chat. In other words, the classic AODV algorithm is for selecting the best route from among multiple routes. Following we deal with how to calculate the route length and performance of AODV algorithm by applying the suggested model.

3.1 performance of algorithm by applying the suggested model

It is assumed that all the nodes are equipped with GPS and know the geographical width and length at any moment. By applying the suggested model in AODV algorithm two new fields of distance and geographical condition is added to the PREP package which are used to calculate the distance between the nodes and each hop to the next node.

Each node which sends the PREP message first put itself in the geographical condition of receiving the PREP and then sends it to the middle node. The receiving node of PREP calculates the distance based on the
length and width related to itself and the node. This process continues so that finally the PREP message reaches the beginning message. So, each middle node shows the distance from final node to the middle node. So the best node is the one with less hop and shortest length.

1) Distance between two nodes = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}

In formula (Cesana, M., et al., 2011), \((x_1,y_1)\) is the geographical condition of the node sending the PREP message and \((x_2,y_2)\) is the geographical condition of the middle node at the side of the receiving.

In addition to the added fields to PREP a new field of route length is added to the records of routing table, the length of which is same as the route length. This field is used for keeping the route length recorded in the table. So, by applying the suggested method in AODV algorithm, the structure of PREP and the records of the table will be in forms of figure 4 and 5.

**Fig. 4:** the existed fields in PREP of new method

<table>
<thead>
<tr>
<th>Distance</th>
<th>Geographic</th>
<th>Number of jump</th>
<th>Lifetime</th>
<th>Source sequence number</th>
<th>Address of the destination node</th>
<th>Address of the source node</th>
</tr>
</thead>
</table>

**Fig. 5:** fields of the records of routing table in each node in new method

<table>
<thead>
<tr>
<th>During the course</th>
<th>Number jump to a destination</th>
<th>Stability of the routing</th>
<th>Lifetime</th>
<th>The next jump to the destination</th>
<th>Destination sequence numbers</th>
<th>Address of the destination node</th>
</tr>
</thead>
</table>

So, applying the new method can increase the number of nodes discovered between the beginning and distant nodes and leads to shortest final route in routing table.

**Evaluating the efficiency of the suggested algorithm:**

**simulating parameter:**

All the simulations for the suggested method are done by simulating the Glomosim (Zeng, X., et al., 1998, the mobile model of the nodes in this simulation is Random Way Point (Perkins, C.E., et al., 2003). The dimensions of the simulating area are 800m * 800m and 1800 m * 1800 m in various simulations and the least radio range in each node was 250m. the distribution model was 2Ray Path Loss and is used in MAC layer of IEEE 802.11 protocol and the band width is 2mbps. The speed of the node movement in simulations was between 0m/s to 10 m/s, the top time was randomly between 10 to 300 seconds and the number of nodes in simulation is from 20 to 70.

Each point had the average of 30 times repetition with the distributed nodes in primary condition. After the primary distribution, the nodes were simulated randomly in the area and moved for 60 seconds to be distributed all over the environment. Then 20 sessions input are started. The dimensions of each package is 512 bit and the ratio of sending is 4 packages in a second. Maximum number of the packages that can be sent in each setting is 60000. So, a mass of 60000 packages can receive by 20 destinations. 20 destinations and beginning points are randomly selected and the movement period is 1800 seconds. All the input session use the CBR traffic models and the number of client and server nodes is randomly selected.

4.2 results of simulation

Simulating the suggested method based on environmental feature and nodes is done in three modes.

1. Simulating in various speeds of nodes: in this mode the number of nodes in 50 and the dimensions of the area is 1000m in 1000m. But the speed of the nodes is from 0 to 10 so that different simulations are done by 0, 0-2 and 2-4 and ….
2. Simulating in various node modes: in this mode the area is 1000 meter in 1000 m, the speed is between 0 to 3 seconds but the number of nodes is from 20 to 70.
3. Simulating in various area dimensions: in this mode the number of nodes are fixed and are considered as 50 and the speed of the nodes are 0 to 30 but the area dimensions is from 800 to 1800 m in 1800 m in simulating the various structure.

**simulating factors:**

In order to evaluate the efficiency of the suggested algorithms and comparing it with AODV three factors of end to end delay, average of broken links and the average of the receiving ration of data packages in different simulating shapes are evaluated. Following the results of the simulation and related charts are represented for three criteria and the effect of suggested algorithms in mentioned criteria comparing the classic AODV algorithms.
end-to-end delay:
The time for transforming the end to end for the package is called delay end-to-end which includes the delays caused by the routing. In this part, the average of the end to end delay for suggested algorithms considering different speeds of the nodes, different numbers of nodes and different dimensions of area are shown in figures 6-8. In all three modes the end-to-end delay is reduced compared to the classic AODV algorithm. It is due to the fact that in shorter routes the links are shorter and sending the data packages need less time so the amount of delay is less than the long routes.

Fig. 6: the average of end to end delay in suggested method and classic AODV in different speeds of nodes

Fig. 7: the average of end to end delay in suggested method and classic AODV in different number of nodes

Fig. 8: the average of end to end delay in suggested method and classic AODV in different dimensions of area
The average of broken networks:
The average number of broken links in simulating with different speeds of nodes, different numbers of nodes and different dimensions of area are calculated based on figures 9-11. As it was seem the mount of broken links are reduced in suggested model. Since by applying the selected routes, the shorter routes are more stable and have more length compared to longer routes.

Fig. 9: the average of broken links in suggested model and AODV in different speeds of nodes

Fig. 10: the average of broken links in suggested model and AODV in different numbers of nodes

Fig. 9: the average of broken links in suggested model and AODV in different area dimensions
Data packet reception ratio:
The number of the received packs in determined goals are called data pack reception ratio. In this part the reception ratio of the packs are shown in figures 12-14. In the suggested algorithm the data pack reception compared to algorithm of classic AODV is increased. Since as it was mentioned before, by applying the suggested routes more fixed routes are selected. Since the ration of break is reduced the ratio of data pack reception is more than the longer routes.

Fig. 12:

Fig. 13:

Fig. 14:

Conclusion:
in classic AODV algorithm after discovering the route, the only criteria for measuring the best route is the number of existed hops in the route which is not proper in some cases since lack of hops in a route are not always due to the shortness of the route. The route with more hops can have less length compared to others. This
article introduces a new method which does the routing in AODV algorithm in multi route form and calculated the length of the routes for discovering the best route to select the shortest route and record it in routing table. The results of simulation shows that the end-to-end delay, the average of the broken links and the average pack reception ratio are improved compared to the classic AODV algorithms.

REFERENCES


