International Journal of Applied Engineering Research, ISSN 0973-4562 Vol. 10 No.45 (2015)

A Novel Link-Utilization Based Cooperative Routing for QOS Aware 802.11e MAC Protocols

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Abstract*— A wireless Ad hoc network is decentralized in nature and routing can be done by all the nodes they are forwarding data to the other nodes. In wireless multihop networks, nodes communicate with each other using wireless channel and it includes partner and relay nodes. Signal to Interference and noise is the major problem in the spatial networks. The proposed work is a novel link utility cooperative based routing for QOS aware 802.11e MAC protocols. By the maximum utilization of the broadcasting procedure of wireless multi-hop networks, the overheard node of the last hop is acting as the partner of transmitter in the current hop. In the link-utility scheme, the nodes are increasing their link utility by adjusting the transmission rate and the power. The node with the peak link utility is selected as the best node and the transmissions can be done through here. But for enhancing this performance in 802.11e protocols a separate link utility based rate switching scheme is maintained. This is for adapting the transmission rate based on the channel's condition. Received Signal Strength Indicator is informing whether to increase or decrease the rate.

Keywords*— MAC, Link-utility, transmission rate, diversity gain, Virtual antenna array, multi-hop networks, rate switching.

I. INTRODUCTION

The two major obstacles of the wireless networks are channel fading and signal-to-interference to understand their ability of delivering packets. Mainly for recovering from these drawbacks, MIMO systems performance is much better. But mounting several antennas in one node is difficult because of the size and the cost calculation. By introducing the cooperative communication, multiple nodes in geographically they can work together with forming a virtual antenna array. Virtual antenna array will leads to improve the signal quality and enhance the performance throughput and energy efficiency.

There are various rate adaptation schemes are introduced before for managing the channel state accurately and for the time-to-time response. Direct rate adaptation scheme can have the two types of adaptations sender-based and receiver-based. They are mainly used to improve the throughput of various wireless networks. Auto Rate Fallback (ARF) protocol [1] is the rate adaptation design based on sender-based for wireless networks. This considers the frame loss as the sign for the channel conditions and adjusts the transmission rate according to the previous transmissions. Holland et.al proposed a RBAR (Receiver-based-Auto-rate) protocol [2], and here the receiver will estimate the channel state by measuring the strength of the request to the RTS/CTS frames and adjust the rate of transmission in one per packet basis. Even though these rate adaptation schemes are being a high throughput and other factors, without the cooperation of nodes, their link utility is poor.

In the existing cooperative MAC protocols [7-11], two phases are needed each time to achieve the cooperative diversity. In these MAC protocols, they are having two phases of communications. Data packets are released by the transmitter in the first phase and these data packets are overheard by the relay nodes while the receivers are receiving at the same time. In the second phase, the data packets are again forwarded to the receiver by the relays in the second phase. When comparing this with the previous non-cooperative protocols, the performance of the above protocols are much better. But the Cooperative MAC protocols are mainly designed for wireless single hop networks.

In the proposed system, the cooperative communication can be designed for the wireless multi-hop networks. For the two phases of communication, in the first phase the neighbor of the receiver receives the data packets along with the corresponding receiver in the first hop. The neighbors of the receiver may have a copy of the data packets will transmit the data packets cooperatively in the next hop along with the transmitter.

A novel link utility based rate switching schemes with the distributed partner or relay selection is proposed for wireless multi hop networks. Mainly in the wireless networks, throughput and energy efficiency are the two major issues.

Here link utility can be defined as the ability to cooperate with the other nodes in the network. Considering the throughput and energy consumption to jointly considering the rate adaptation and power control. In link utility based rate switching, transmitter as well as the nodes will calculate the maximum achievable link utility values independently by executing the back off scheme. In the case of the back off timer, timer is adjusted to each node and the node which is first expiring the back off timer is said to be as the best node. Then the link utility based rate adaptation scheme can be used to transmit the best nodes according to their turn and with their method. This method is different from the existing sender-based and receiver-based rate adaptation schemes. Extensive simulation results will compared with the IEEE 802.11e standard. With the simulation results, link utility based rate adaptive scheme will significantly improve throughput, energy efficiency and reduces delay.

II. Related Work

S. Cui et.al discussed the MIMO techniques and the cooperative communication [3] [4] of the physical layer for improving the whole system performance. Distributed Space-coded protocols for achieving cooperative diversity was discussed by J.N Lemenarnand [6]. Many cooperative MAC protocols are based on the Space-time coded cooperative diversity and are successful in coordinating the operations of distributed nodes. H. Zhu et.al proposed a r-DCF cooperative protocol for the wireless ad hoc networks. They tried to improve the low throughput which was caused by low data rate nodes. For this kind of nodes, both r-DCF and cooperative MAC will provide faster transmissions with the two multi-hop networks. This will significantly improve the throughput. But its link utility is very poor.

The Proactive table-based relay selection procedures are not suitable for time varying channels. Here for improving the throughput, a technique called Maximum Ratio Combining technique was introduced by the receiver side for combining the data from the transmitter and the relay [9], [10]. Goturk et.al [11] proposed a medium access control protocol, which is coordinating the transmitter and relay nodes to transmit the packets to the receiver simultaneously in the next phase. A cooperative relay-based auto rate MAC protocol was proposed by T. Guo et.al and herd on the based on the instant values of channel measurements, the relay nodes making themselves as relays and also they are determining the relay schemes.

H. Shan et.al proposed a cooperative triple busy tone multiple access scheme and in these methods it is showing the capability of the helping nodes for the proper transmission of other nodes. A cooperative diversity medium access control protocol was proposed in existing systems. Here each node is selecting one relay proactively and if the transmission fails the space time coded packets were transmitted between the sender and the relay simultaneously. Jaklari et al. proposed a multi-layer approach with the help of multiple-input single-output antennas to find shorter paths and which helps in increasing their throughput and reducing the delay. A Multiple-input multiple-output MAC protocol for improving the energy efficiency and here the sending groups and the receiving packets are on one packet at a time. In this paper, we address the problem of selecting a suitable helper node which can receive the data packet in the current hop and transmit the data packets in the next hop. For improving the energy efficiency of the multi-hop networks a link-utility based cooperative protocol with MAC was proposed.

III. Preliminaries

A. *Transmission in Multi-hop networks*

1. Reception Model

When comparing the performance of Single-Input Single-Output (SISO) system with MISO system, MISO achieved the better performance. This is because the reception threshold for the MISO is somewhat lesser than the SISO link.

2. Network Model

In the figure, when a source node S wants to communicate with the destination node D, the direct path between S to D is denoted S→A→ B→ D and it was already established with the help of the routing protocols. In link utilization based MAC protocol, the cooperative path can be constructed with the combination of One phase cooperative transmission (1 phase CT1) or two phase cooperative transmission (2 phase CT2) or direct transmission DT. In the proposed Link utilization based protocol, the transmitter and the helper nodes will calculate their maximum link utility independently at the time of transmissions. If the partner node has the maximum link utility the one phase transmission or two phase transmissions are followed. Otherwise the direct transmission will be followed.

If the direct link utilities of the nodes are good and the link utility of the transmitter is good, then direct transmission will be followed in the first hop. Here S is considered to be as the transmitter and A is said to be as the receiver. In the second hop, F is acting as the partner node and F has already increased its Link utility by overhearing the message at the time of direct transmission. Now the One phase Cooperative transmission is activated. Now S is the transmitter, F is the partner and B is the receiver. Now for sending the data packets to the destination, the two phase cooperative transmission is followed in the third hop. Now B is acting as the transmitter and L is the relay and D is the receiver. Now the cooperative transmission path is given to be as,

$$S \rightarrow \{A, F\} \rightarrow B \rightarrow C \rightarrow D$$

IV. Proposed System

In the proposed system, the cooperative communication can be designed for the wireless multi-hop networks. For the two phases of communication, in the first phase the neighbor of the receiver receives the data packets along with the corresponding receiver in the first hop. The neighbors of the receiver may have a copy of the data packets will transmit the data packets cooperatively in the next hop along with the transmitter.

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multi hop networks. Mainly in the wireless networks, throughput and energy efficiency are the two major issues. Here link utility can be defined as the ability to cooperate with the other nodes in the network. Considering the throughput and energy consumption to jointly considering the rate adaptation and power control. In link utility based rate switching, transmitter as well as the nodes will calculate the maximum achievable link utility values independently by executing the back off scheme. In the case of the back off timer, timer is adjusted to each node and the node which is first expiring the back off timer is said to be as the best node. Then the link utility based rate adaptation scheme can be used to transmit the best nodes according to their turn and with their method. This method is different from the existing sender-based and receiver-based rate adaptation schemes.

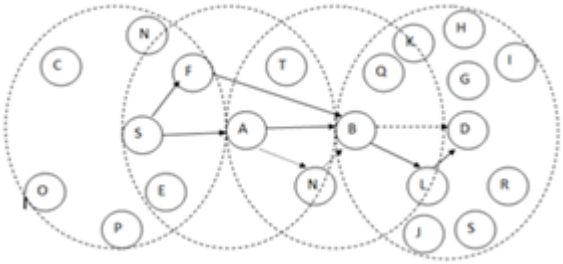

Fig 1: Multihop networks cooperative communication

A. *Back off Scheme*

In the link utility based cooperative MAC protocols, an efficient back off procedure is followed for modifying the link utility scheme. In the back off scheme, the nodes are trying to participate in transmission based on three contention groups. They are inter-group, intra-group and re-contention mechanisms.

1) Contention based on inter-group:-

In this case when the transmitter receives the clear-to-send frame, the transmitter node, all the partner nodes and the relay nodes are maintaining their link utility values. Then they are entering into the group of Inter-group contention. This method is best for reducing collisions. Inter-group contention will partition into G group. This can be given to be as group indicator GI. Here they are struggling to transmit inside to the group.

2) Contention based on Intra-group:-

After the contention of Inter-group, then the next group which is called as signaling group enters in intra-group contention. The members with index based on m should reply for the indication MI. The intra-group contention will be taken outside the transmitting node and other nodes are still contending.

B. *Link utilization with Adaptive Rate Swithching Algorithm*

In the link utilization mechanism cooperative communication procedure is followed. Here the Inter group contention period, Intra group contention period and re-contention period are used for selecting the best node for the cooperative communication. In the link utilization based rate switching mechanism, the transmitter itself is adjusting the transmission rate and power of the channel simultaneously. Initially the transmitter is selecting a suitable ratio of number of nodes, channel capacity and the power. If the channel is good and if it is getting the acknowledgements properly it sets for increasing the range of transmission. If that limit is not successful it selects the previous history. The Received Signal strength indicator is used to give the information about the channel and also whether to increase or decrease the transmission ratio.

V. Simulation Results

The simulations were performed in Network Simulator 2 under the comparisons of CRBAR and RBAR with the proposed Link utility scheme. In the simulations, the source node is always having data packets to send to the receiver. Simulations are evaluated under two parameters they are throughput and energy efficiency.

- Throughput: Number of data bits received successfully to the destination in unit time.
- Energy efficiency: Energy efficiency is defined as the energy consumed for successfully transmitted data bit to the destination.

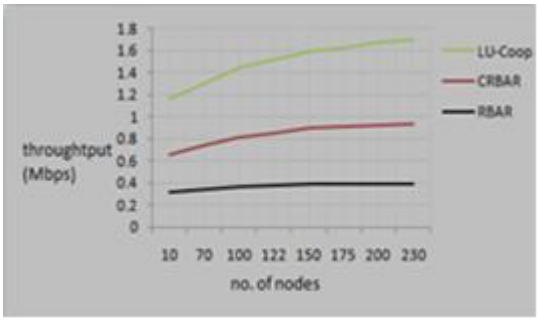

Fig-> a) Throughput

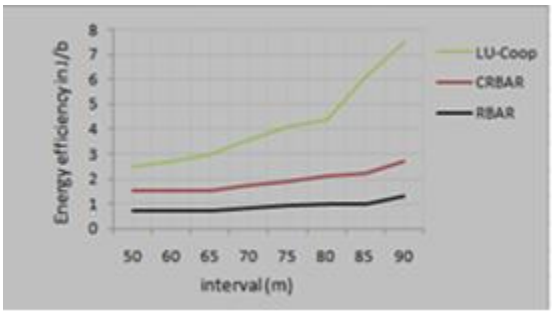

Fig-> b) energy efficiency

For fully evaluating the performance of link utility based cooperative network with the protocol parameters L an c in the simulations. The total number of nodes are said to be 200 and the interval in the simulations are given by 75m. In the simulation the throughput performance is evaluated with the LU Coop, CRBAR and RBAR with different node density and variable packet size. From the graph we know that the performance of LU coop and CRBAR are significantly high

because of its cooperation property and decrease of performance in RBAR. As the number of node increases, the helper nodes also increases and it leads in finding best nodes. Then the energy efficiency for the above three schemes are compared with respective of various intervals. In the second graph, as the interval increases , the throughput performance of all schemes degrades since the channel condition get worse. Because the throughput performance can be effectively improved through cooperation. So LU coop and CRBAR perform better than RBAR. The performance of LU coop is highly increased because of overheard function and reduced data transmission time

VI. CONCLUSION

A novel link-utilization-based cooperative routing for QOS aware IEEE 802.11e MAC (LC-MAC) protocol with Adaptive rate switching is proposed. By mentioning the problem of selecting the best helper node which helps in receiving the data packets in the current node hop and transmit the packets of data in the next hop. For this purpose one-phase cooperative transmission is maintained. In Link utilization based rate switching mechanism,for maximizing the link utility capacity, the nodes are jointly adjusting the transmission rate and power with per packet basis. Using back off procedure, to carry out the data transmission, the best node is selected. Finally, the simulation results are showing that Link utilization procedure can improve the performance of throughput and energy efficiency compared to other rate adaptation techniques.

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