Performance evaluation of Cooperative MAC and ZRP in Cooperative Communication Networking Environment

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Abstract -*The concept of cooperative communication has been proposed to improve link capacity, transmission reliability, network coverage and cooperative transmission ranges in multiuser wireless communication networks. Cooperative communication allows multiple users or stations in a wireless network to coordinate packet transmissions and share each other's resources, thus achieving high performance gain, better service coverage and enhanced cooperative transmissions ranges. According to the IEEE 802.11 standards, wireless local area networks (WLANs) can support multiple transmissions data rates, depending on the instantaneous channel condition between a source station and an access point (AP). In this work a Cooperative Medium Access Control (CoopMAC) protocol, in which high data rate stations assist low data rate stations in their traffic. Extensive simulation results validate the mathematical models developed and show that CoopMAC protocol can significantly improve system throughput, service delay and energy efficiency for WLANs operating under realistic communication scenarios.*

Key Words: Wireless networks, Cooperative communication, CoopMAC

1. INTRODUCTION

Cooperative communication is a promising method for improving the performance of wireless networks. The diversity gain provided by the cooperation among nodes can be utilized to mitigate the effects of fading [1]. The idea of cooperation among nodes is similar to the multiple-input, multiple-output antenna (MIMO) approach which provides diversity by putting multiple antennas on a wireless node [2].

The cooperative communication can provide diversity by virtually using the relays as supportive antennas for the original transmission hence it's sometimes called virtual MIMO. The cooperative communication is capable of providing significant performance gains for the wireless channel due to the fact that fading occurs independently in each link [3].

Cooperative communication has emerged as a promising technique for improving reliability in a wireless environment. In cooperative communication, neighbouring relay(s) cooperate with the transmitter-receiver pair to deliver multiple copies of a packet to the receiver via independently fading channels. These neighbouring relay(s) can be employed for cooperation to retransmit a (possibly processed) copy of the overhead packet to the destination. The destination can combine these packets, received from the source and neighbouring relay(s), thereby exploiting spatial diversity to recover a packet. This reduces end-to-end propagation loss, and improves coverage.

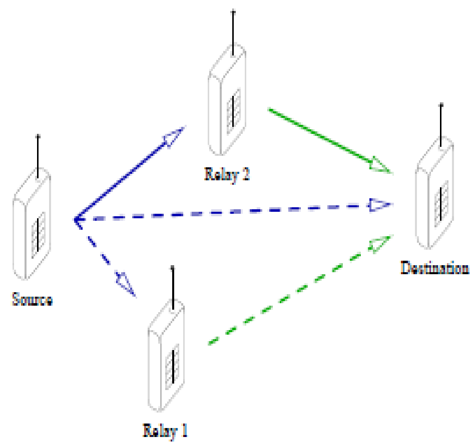

Figure 1: Multiple-Input Multiple-Output antenna (MIMO) approach

Cooperation communication scenario leads to interesting trade-offs in code rates and transmission power at the source. In the case of transmission power, one may conflict for usage of more power for each user, whereas in cooperative mode, it's done for transmissions to both users. On the other hand, the baseline power transmissions for both users are reduced due to diversity. In the case of trade-offs, one always insists for reduction in net transmission power, given everything else to be constant.

The IEEE 802.11 protocol employs carrier sense multiple access with collision avoidance (CSMA/CA) as its medium access protocol for the distributed coordination function

(DCF) mode [4]. In this mode, each station can initiate a data transmission by itself. Channel sensing before packet transmission is essential to avoid collisions. If one station has packet to send, it will first sense the channel to make sure the channel is clear before the actual transmission starts. Since not all the stations can hear each other, even if the channel is sensed to be free, a collision may occur. Thus virtual carrier sensing is also employed with the use of Request To Send (RTS) and Clear To Send (CTS) frames to reserve channel time for the transmitting stations. These two control frames broadcast the channel reservation information to the whole network.

2. RELATED WORK

In this paper, two modes of transmissions is used i.e., Direct mode which is the legacy mode under the Carrier Sense Multiple Access (CSMA) protocol (no cooperation) and Cooperative mode which is the mode that enables CoopMAC. In the direct mode communication, the packets from the source station are transmitted to the destination station in a single hop only when the destination station is in the transmission range of the source station. In the Cooperative mode communication the packet is forwarded to the destination through the helper nodes using fast hops as shown in Figure 2. The decisions about which set of helper nodes are used are selected by the source based on the criteria of datarates tabulated by the Coop table which is determined by the control packets (i.e. modified CTS and modified RTS).
The modified control packets tabulates the neighbouring helper node(s) data rates in a defined table called Coop Table, where the source station decides which helper node(s) to be selected under cooperative mode transmission [5].

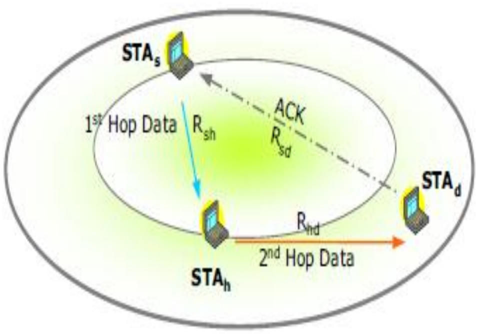

FIG2: DATA PLANE OPERATION OF COOPMAC

Definition of Performance parameters used in Simulation

a. *Average end-to-end delay (average E2E delay)*

The time spent by the packets to reach to the destination. The average end-to- end delay is calculated by adding all the times taken by all received packets divided by their total numbers. This rate is preferred to decrease [6].

b. *Packet Delivery Ratio (PDR)*

The ratio of the amount of received data and the total data that the source node delivered shows the transmit efficiency from this parameter [7].

3. EXPERIMENTAL RESULTS

We evaluated the performance of the proposed protocols assuming static network topologies. Since our main goal is to observe the impact of cooperation decisions in routing, we consider the case of a single flow to determine the achievable cooperation gains.in the following results, we assume the path selection

In our experiments we use a basic setup of three stations, one source, one destination and a helper. We ran different experiments changing the position of the helper between the different regions by forcing the data rates between the source, helper and destination nodes. For every position of the helper, packets were transferred from the source to the destination with and without cooperation from the helper node.

Our first experiment was a packet transfer of a source that transmits directly to the destination at data rate of 2 Mbps was compared with the file transfer time if the same source received assistance from helper node at various higher transmission rates. In Coop MAC protocol we have tried to modify the RTS and CTS packet and also created new control packet called HTS and further calculated the time required to identify helper node to send the data packet through it. CoopMAC performs better, resulting in shorter transmission times for the files. We repeat the same experiment, with a data rate of 1 Mbps data rate for direct transmission between the source and the destination. We also have considered the number of nodes in a layout to 15, 50 and 100 nodes respectively.

FOR NODES LAYOUT OF 15 NODES

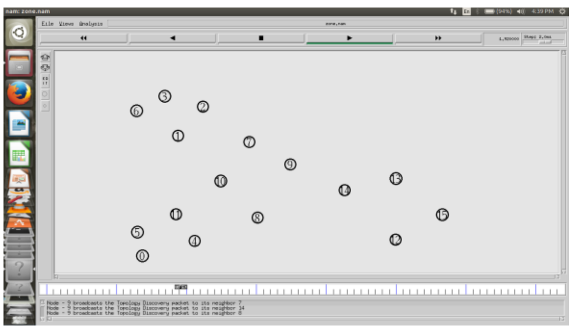

FIG 3: ARCHITECTURAL LAYOUT OF 15 NODES

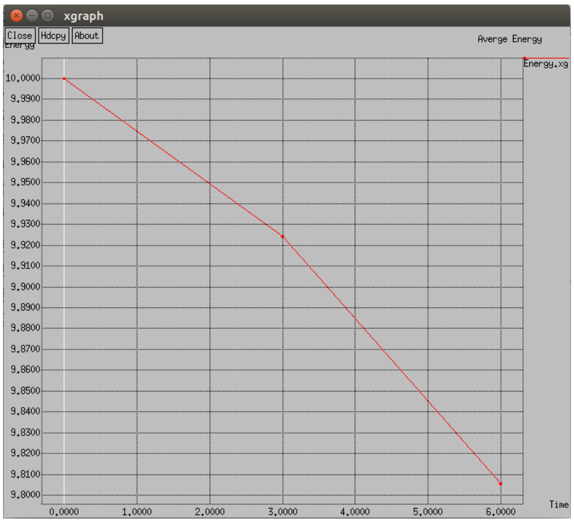

FIG 4: AVERAGE ENERGY OF THE PACKET

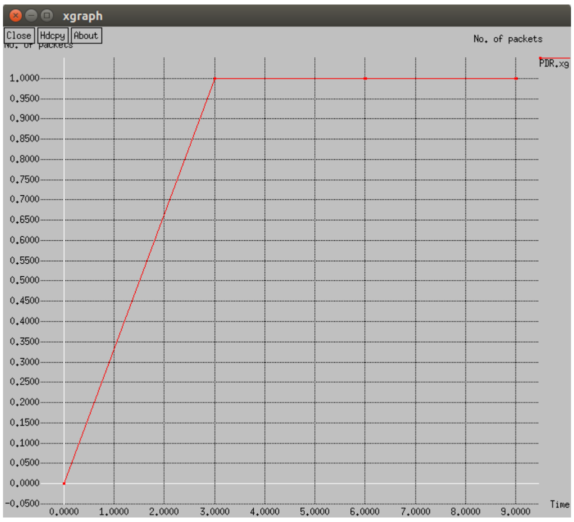

FIG 5: PACKET DELIVERY RATIO

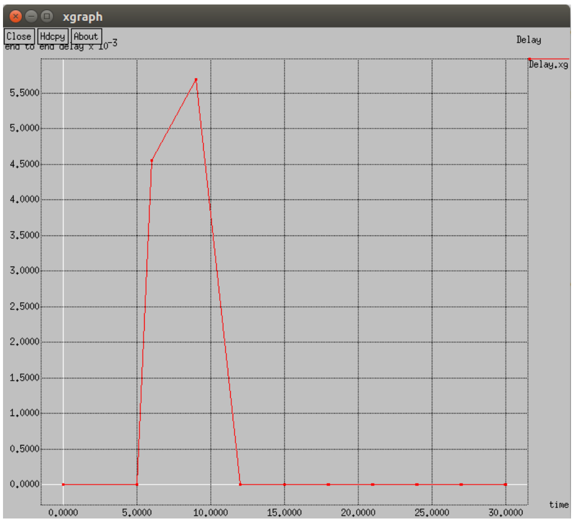

FIG 6: PACKET DELAY

FOR NODES LAYOUT OF 50 NODES:

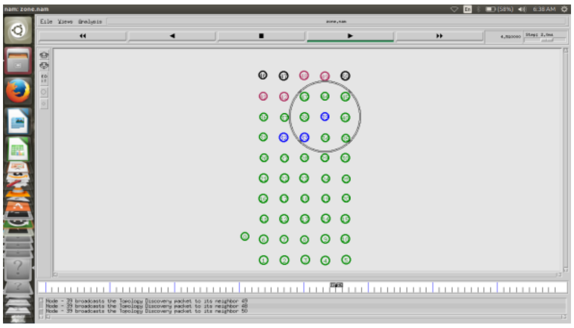

FIG 7: ARCHITECTURAL LAYOUT OF 50 NODES

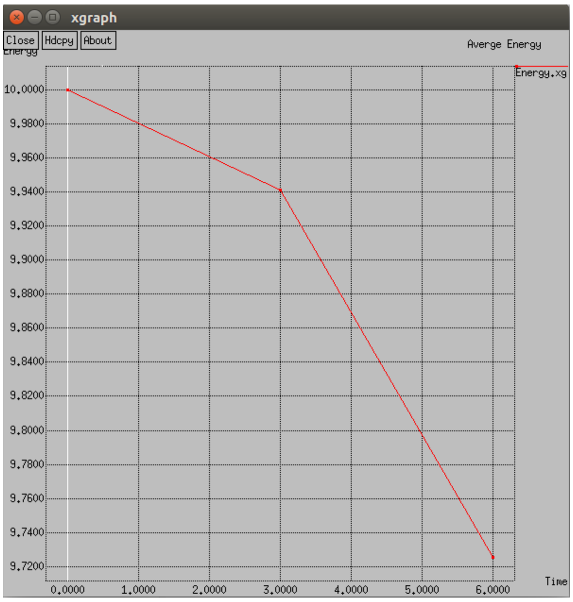

FIG 8: AVERAGE ENERGY OF THE PACKET

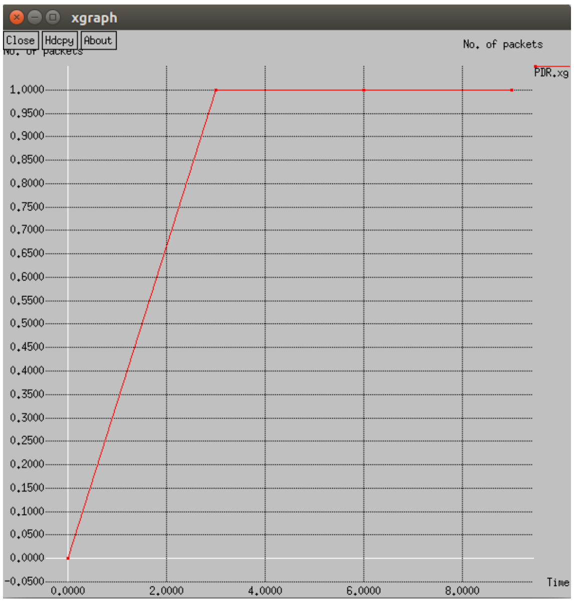

FIG 9: PACKET DELIVERY RATIO

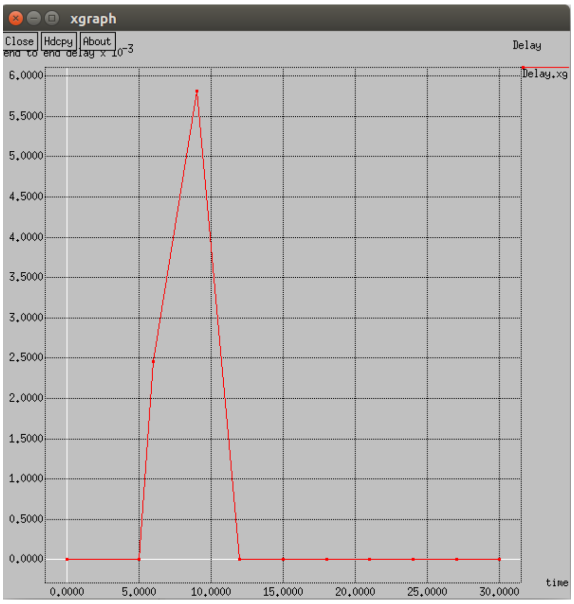

FIG 10: PACKET DELAY

FOR NODES LAYOUT OF 100 NODES:

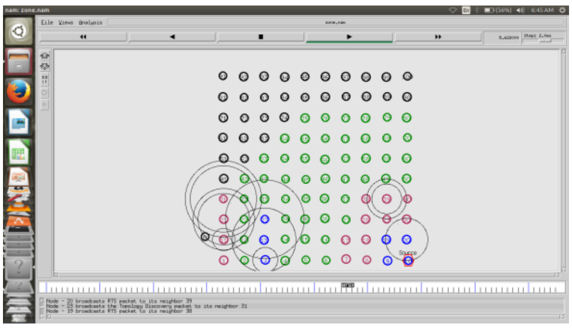

FIG 11: ARCHITECTURAL LAYOUT OF 100 NODES

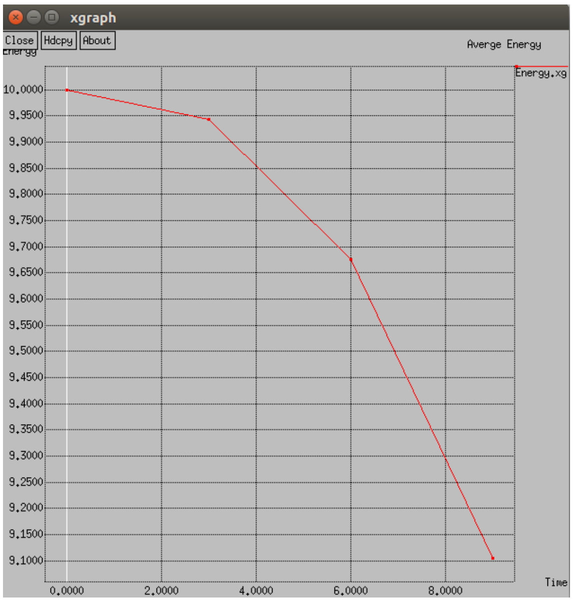

FIG 12: AVERAGE ENERGY OF THE PACKET

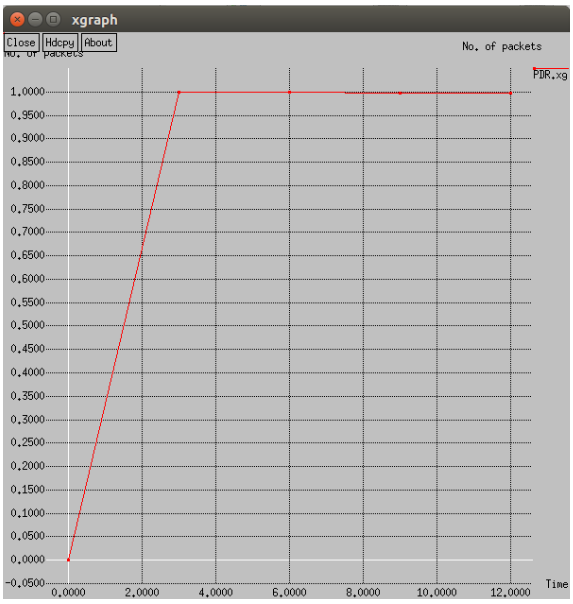

FIG 13: PACKET DELIVERY RATIO

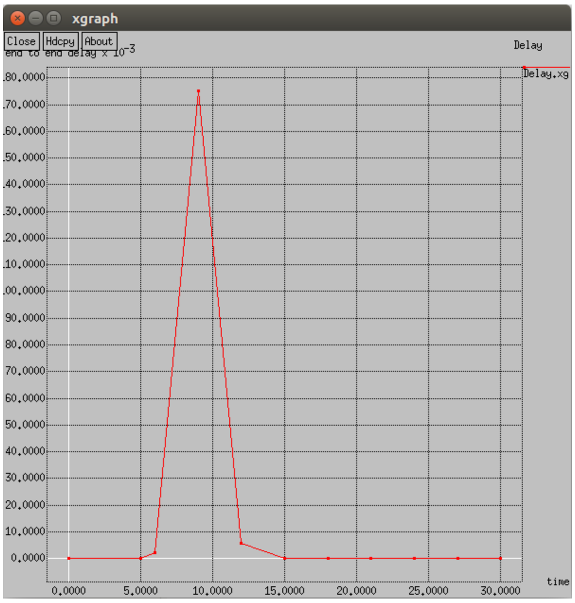

FIG 14: PACKET DELAY

For implementation of routing protocols, we used Tool Command Language (TCL). The output of a TCL code is two file types with the name of Network Animator (NAM) file and Trace file (Tr). In order to elaborate the results from the trace files we used "awk" command. This command is a powerful control command in Unix that can process the rows and columns of a file. The results are shown in the following figures.

PACKET DELIVERY RATIO VS TIME IN ZONE ROUTING PROTOCOL

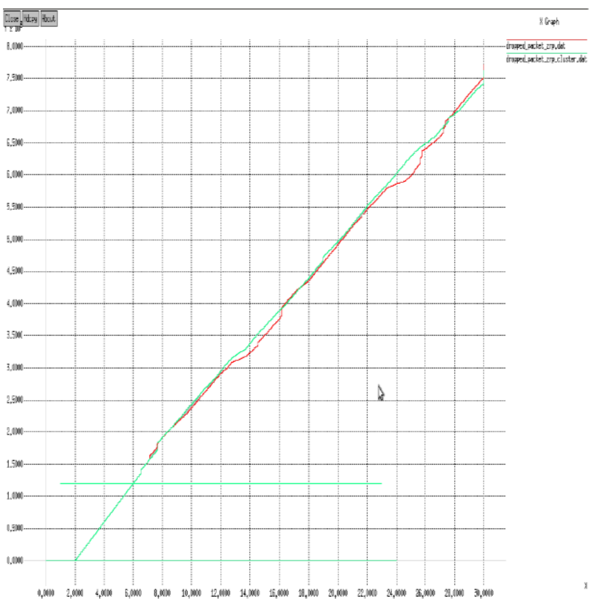

FIG 15: PACKET DELIVERY RATIO VERSUS TIME IN ZONE ROUTING PROTOCOL

Fig. 15 shows the result of simulation of Zone Routing Protocol in terms of Packet Delivery Ratio. The CoopMAC protocol provides a better average end to end delay.

PACKET DELIVERY RATIO VS TIME

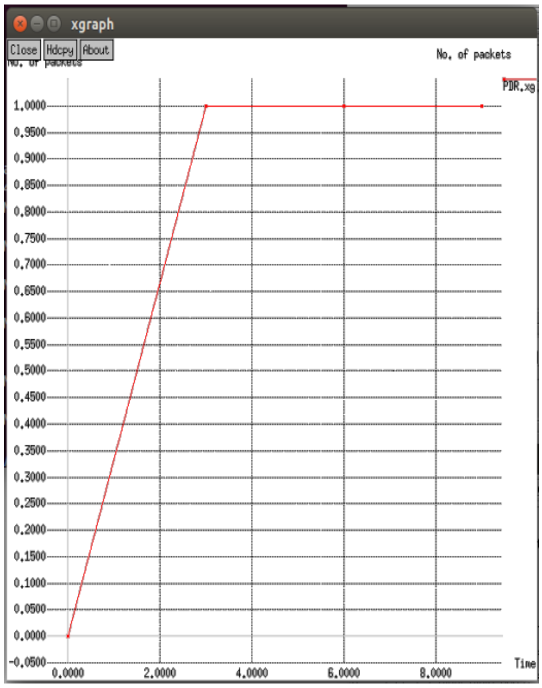

FIG 16: PACKET DELIVERY RATIO VERSUS TIME IN COOPMAC

Fig. 16 shows the result of simulation in term of the packet delivery ratio. The CoopMAC protocol provides a better Packet delivery ratio.

3. CONCLUSIONS

In this paper, we a modified proposed cooperative MAC which enables and supports the cooperation among neighbouring nodes by taking advantage of the control message exchanges in the local neighbourhood. We simulated CoopMAC protocol which belongs to legacy cooperative communication by NS2 simulation tool, and evaluated and analysed the packet delivery rate and End to End delay. Choosing the best protocol is totally related to the size of the network.

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