A COOPERATIVE COMMUNICATION PROTOCOL IN WIRELESS MOBILE AD HOC NETWORK

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Abstract : Now a day the speed is the very important parameter of wireless Ad Hoc network. Cooperative communication leverages the broadcast nature of the wireless channel and spatial diversity, achieving improvement in system capacity in term of throughput and delay. We design new MAC protocol in wireless Ad Hoc network based on the idea of involving in ongoing communication an intermediate station (relay) that is located between transmitter and receiver. Intermediate station acts as helper forward to the destination; traffic is received from the source. Thus the slow transmission is transformed into faster one or two relay transmission. So the MAC protocol improves the Ad Hoc network performance in terms of throughput.

IndexTerms – cooperative communication, MAC layer, Ad Hoc network

I. INTRODUCTION

The notion of cooperation takes advantage of the broadcast nature of the wireless channel and creates spatial diversity, achieving improvement in system robustness, capacity, delay, a significant reduction in interference, and extension of coverage area cooperative communication present a new protocol design example for wireless communications. the initial makes an attempt for developing cooperative communications focused on physical layer schemes. This approaches talk to the cooperative communication and retransmission of the overheard data at those stations surrounding the source and also the destination. By combining different copies of constant signal transmitted by source and different relay stations, the destination will improve its ability to decode the original packet The innovation of cooperative communications is not cramped only to the physical layer. It is available in various forms at different higher protocol layers. A mac protocol known as Coop MAC illustrates however the legacy IEEE 802.11 distributed coordination function(DCF) [8] are often increased with least modifications to maximise the advantage of cooperative diversity.

In this paper we tend to propose and study a cooperative mac protocol for ad-hoc wireless networks. The protocol relies on Coop MAC functionality and is adapted to work efficiently within the ad-hoc network. in such a case, a relay or helper, placed somewhere between the transmitter and the receiver, is used to boost the slow communication. The transmitter, instead of sending its packets on to the receiver at a low rate, uses the helper to transmit the packets in two high-rate hops, so decreasing the transmission time. during this method, the actual communication lasts less time, resulting not only within the improvement of the throughput of the transmitter however additionally within the increase of spatial reuse, within the sense that neighbouring stations will initiate a new transmission earlier than they otherwise would have.

In IEEE 802.11b, the physical layer uses direct sequence spread spectrum (DSSS) in 2.4 GHz ism band. There square measure 3 totally different modulation ways, i.e., the Differential Binary phase Shift Keying (DBPSK) with 1Mbps rate, the Differential quadrature phase Shift Keying (DQPSK) with 2Mbps rate, and also the Complement Code Keying (CCK) with data rates of 5.5 Mbps and 11 Mbps. The bit rate of control frame and also the head of data frame square measure at a base rate, i.e. 1Mbps. The physical layer head within the IEEE 802.11 describes the modulation scheme of the information payload. so as to satisfy the requirement of bit error rate, the IEEE 802.11 protocol transmits the data payload in a variable rate according to the channel quality. In general, the transient path loss and channel attenuation have an effect on the physical transmission rate.

IEEE 802.11 Distributed Coordination function (DCF) adopts Carrier Sense Multiple Access (CSMA) with Collision avoidance (CA) because the mac protocol. during this approach, each site itself will start a frame transfer method. thanks to the hidden terminal problem, the nodes cannot hear the nodes exceed the wireless transmission distance. though the nodes sense the channel is idle, collision should occur. DCF uses the virtual carrier sensing to reserve the transmission time. attributable to the broadcast characteristics in wireless transmission, the neighbouring nodes of the source and therefore the destination will receive a minimum of one frame in the RTS and CTS handshaking. All the neighbouring nodes obtain the time duration of the continuing transmission from the Network Assignment Vector (NAV) field within the frame head, and stay silent until the current transfer finishes.

The expedient adaptive rate adjustment protocol sends multiple data frames continuously when the channel quality is good to make full use of the channel capability. However, it exists an unfair problem. within the cooperation mac protocol, every station maintains a relay candidate table, and looks up the table to see whether or not there's a relay will improve the transfer rate before data transmission.

Based on existing analysis, we have a tendency to propose a Relay based Media Access control (Relay-MAC) protocol. every node within the network listens on the ongoing transmission of control frames, obtains the channel quality between the source and the destination, and decides whether or not to participate within the relay forwarding in an exceedingly distributed manner.

II. Network View

Consider a wireless ad hoc network with one physical channel employs the IEEE 802.11b technology, as shown in Fig. 1. assumptive that the wireless links between the neighbouring nodes are symmetrical, the transmitting power of every node is fixed, and take the free space loss model, i.e., the received signal strength principally depends on the space between supply and destination. every node transmits the info payload at an acceptable rate, even so, transmits the control frame at the base rate.

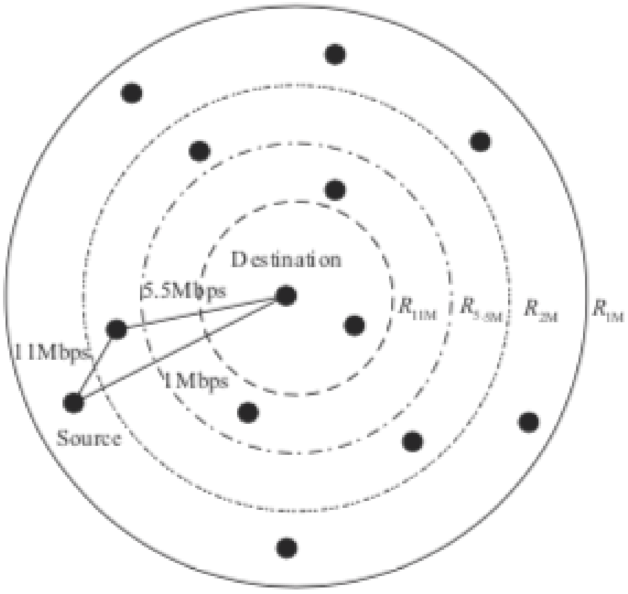

Fig.1 multiple rate transmission network (picture courtesy: Koraris et al. 2007)

III. Designing of MAC Protocol

Frame

The basic access mechanism, called the Distributed Coordination Function, is a Carrier Sense Multiple Access scheme with Collision Avoidance (CSMA/CA), where a station is allowed to initiate a data transmission if it senses that the medium is idle (i.e., no other station is transmitting). Request To Send (RTS) and Clear To Send (CTS) control frames are used to reserve channel time and prevent neighbouring nodes from simultaneously transmitting, as shown in Figure 1.4. Here, DIFS (Distributed Inter-Frame Space) and SIFS (Short Inter-Frame Space) are used for frame spacing. Frame spacing allows assigning priorities to a transmission based on its type (control or data frame). The control frames (RTS/CTS) include the source node address, destination node address, and a Network Allocation Vector (NAV) that specifies the duration of time that the medium will be busy.

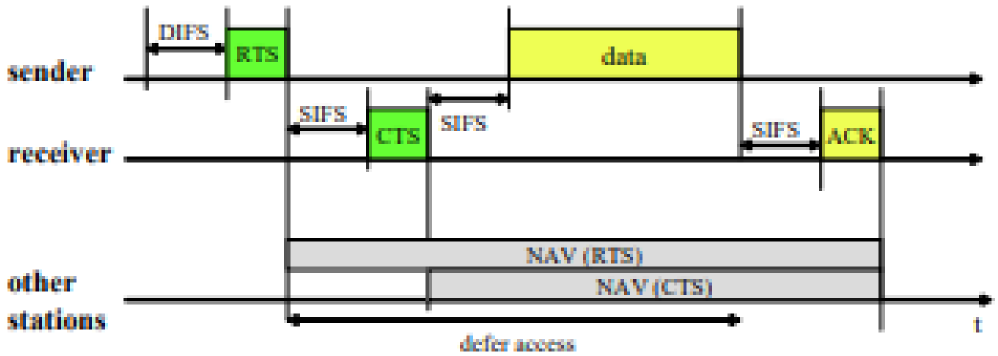

Fig 2. data frame (picture courtesy : Wang et al. 2017)

***Relay Selection* :**

In a scenario with N contending stations randomly distributed around a common AP, throughput performance depends on the channel conditions experienced by any station in the network. Consider a contending station at a distance d from the AP. Given the one-sided noise power spectral density, No = −174 dBm|T =273K , the received SNR can be evaluated as :

$$SNR_{dB} = P(d)\ \big|_{\text{dBm}} - N_o - B_w\ \big|_{\text{dB}} - N_F$$

whereby NF is the receiver noise figure (10dB).
P(d)|dBm , the power received at a distance d, corresponds to

$$P(d)\ \big|_{\text{dBm}} = -\,\text{Ptz}\ \big|_{\text{dBm}} - PL_{dB}\ \big|_{\text{dB}}$$

Based on FCC regulation in the 2.4 Ghz ISM band the transmitted power Ptx amount 20 dBm or equivalently,100mW,while PLdb is so called path-loss

$$PL_{dB} = PL_o \mid_{\text{dBm}} + 10\, N_P - \, log_{10} \frac{d}{d0}$$

Whereby,

$$PL_o \mid_{\text{dBm}} = 10\, log_{10} \frac{GtGr\lambda e2}{4\Pi e2d0}$$

The path-loss exponent ηp, depends on the specific propagation environment and its range from 2 to 3.5-4 for non light-of- site propagation or multi-path fast fading condition, in indoor environment.

The SNR per transmitted bit,γ is define as,

$$\gamma \mid_{\text{dBm}} = \text{SN}\, R_{dB} + 10 log_{10} \frac{Cs}{Bs}$$

Whereby Cs stands for chip per symbol, while Bs is number of bits per transmitted symbol , both Cs and Bs are summarized in table 1 BER performance of the various transmitting mode of IEEE802.11b are shown in below for Rayleigh fading conditions

$$DBPSK = \frac{1}{2(1+\gamma)}$$

$$DQPSK = 1 - \frac{\sqrt{\gamma^{2/2}}}{1+\gamma^{2/2}}$$

Where by α = 4 for 5.5Mbps and 8 for 11 Mbps

Consider a fixed number of contending stations. In saturation conditions, each station has immediately a packet available. for transmission, after the completion of each successful transmission. Moreover, being all packets "consecutive," each packet needs to wait for a random backoff time before transmitting. Let be the stochastic process representing the backoff time counter for a given station. A discrete and integer time scale is adopted: and correspond to the beginning of two consecutive slot times, and the backoff time counter of each station decrements at the beginning of each slot time. Note that this discrete time scale does not directly relates to the system time. In fact, as illustrated in Fig. 1, the backoff time decrement is stopped when the channel is sensed busy, and thus the time interval between two consecutive slot time beginnings may be much longer than the slot time size , as it may include a packet transmission. In what follows, unless ambiguity occurs, with the term slot time we will refer to either the (constant) value , and the (variable) time interval between two consecutive back off time counter decrements.

IV. Performance Evaluation

Once network designed then it will used for the evaluation performance metrics: 1) delay, 2) average throughput

Average Delay

The delay in network measured based on the average time which data packets transmission from source nodes toward the destination however since delays initiated based on these buffering, queuing and propagation delays. Thus, average delay somewhat depends on packet transmission. When distance increased between source and destination, probability of the packet drop is also increased [20]. The mathematically formula of average delay (D) and sum of total packets delivery successfully (n) in this scenario shown in equation (1).

$$Average\ end2end\ delay = \frac{\sum_{i=1}^{n}(Received\ Packet\ Time - Send\ Packet\ Time) * 1000(ms)}{Total\ Number\ of\ Packets\ Delivery\ Successfully} \quad (1)$$

Average Network Throughput

The average network throughput expressed the sum of total data packets which successfully reached to destination at given simulation time. Based on mathematical calculation of throughput shows, here PacketSize is indicate to size of ith packet reaching to destination, Packet Arrival is the time when last packet arrived and PacketStart is the time when first packet arrived to destination.

$$Throughput = \frac{PacketSize}{(PacketArrival - PacketStart)} \quad (2)$$

The simulation parameters of network model are shown in Table 1. The performance comparison analysis based on different scenarios:

Table 1 simulation parameters

Parameters	Values
Network Simulator	NS2.35
Routing Protocols	DCF
Standard	IEEE 802.11 & CoopMac
Number of Stations	15, 40, 60, 80, 100, 120 and 150
Simulation Area	900 × 900
Simulation time	1000 Second
Application Layer	UDP
Traffic type	CBR
Antenna	Omni-directional
Channel	Wireless
Radio-propagation pattern	Two ray ground
Interface queue	Drop/Tail/PriQueue
Network interface mode	Phy / WirelessPhy
Performance Metrics	Delay and Average Throughput

1. Number of stations

Figure 3 reveal the relation between the network through- put and also the number of stations deployed. The MSDU packet size is 1024 bytes. to get the system capability, the network is saturated and every station is in a very backlogged state. it's apparent that the cooperative mac significantly outperforms IEEE 802.11b. Indeed, the Cooperative raincoat protocol is anticipated to deliver more throughput than the legacy IEEE 802.11 DCF due to many reasons: first, it accelerates the slow transmissions by replacing them with quicker two-hop transmissions. Second, the proposed protocol not solely improves the performance of slow stations, however additionally makes it possible for fast stations to access the channel earlier, because the data transmissions from slow stations take significantly less time. An interesting point that has to be investigated in an environment of a dense ad-hoc network, is whether or not spatial reuse is benefited or harmed by cooperation. this can be not a straightforward issue.

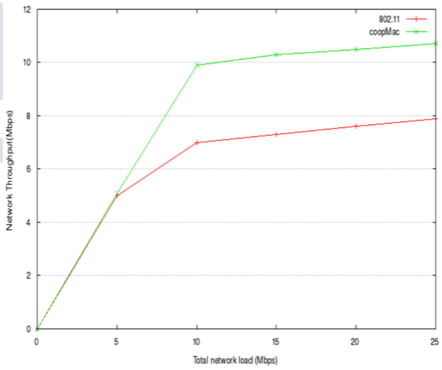

Fig. 3 Number of stations Vs throughput graph

2. MPDU size in bytes Vs throughput

Figure 4 depicts the network throughput because the total load will increase. The network consists of 150 stations and therefore the MPDU size is 1024 bytes. For low load the performance of 802.11 and our cooperative protocol is similar. this can be because of the very fact that during a low load the transmission of the frames is quite rare and therefore the time a station occupies the medium to transmit the frame isn't critical for the performance of the network. In other words, during this case there square measure enough bandwidth resources for transmission of the network traffic even at low link rates.

Figure 4 gives the throughput comparison because the MPDU size will increase. we will see that for large MPDUs cooperative mac outperforms IEEE 802.11. this can be something we have a tendency to expect to visualize and it's explained based on the advantages of cooperation that we have a tendency to mentioned within the previous paragraphs.

On the other hand, once the MSDU is quite small (less than 140 bytes) there's no benefit from cooperation. a detailed look shows that during this case not only there's no benefit from cooperation however the proposed protocol performs exactly the same as 802.11. the reason to those statements comes from a more careful examination of the protocol details.

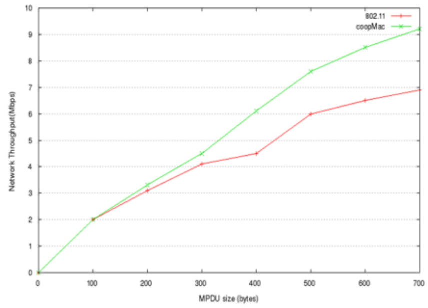

Fig. 4 MPDU size Vs throughput

3. CDF for service delay for 50 or 150 stations

Delay is another performance metric important for a wide variety of applications. Figure 5 depicts a cumulative distribution for the service delay. The simulation is for a network of 150 stations with a packet size of 1024 bytes and a lightweight network load. each station features a buffer size of 30 frames. the whole delay refers to the time from the moment the packet arrives at the mac layer until the moment the packet is with success transmitted. Figure 5 shows a cumulative distribution for the service delay for a network of 150 stations, with a packet size of 1024 bytes and a lightly loaded network traffic. The service delay refers to the time it takes for a packet to be with success transmitted after it becomes the head-of-the-line (HOL) packet in a very buffer of a station. we will see that the delay of our protocol is significantly lower than that of IEEE 802.11 in each cases. this can be because the Coop MAC decreases the TRM of slow rate frames and thus more frames can be transmitted in a very given period of time, a fact that decreases the queuing and service time of the frames.

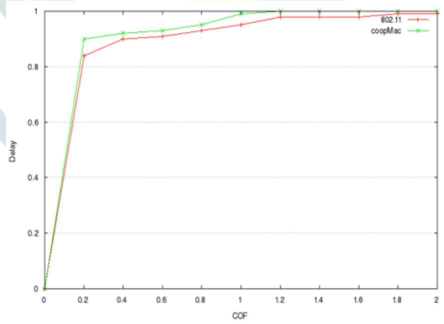

Fig.5 number of station Vs Delay

V. Conclusion :

In this paper, study a cooperative mac scheme for ad- hoc wireless networks. we tend to measure its performance victimization simulation results from a large scale network of 150 stations. The thorough study shows that the cooperative protocol out- performs IEEE 802.11 in most of the cases and set up a base for considering the use of cooperation at the mac layer as a solution to the constraints on traditional protocols in dense network setting. As for future work, cross layer approaches are going to be considered, combining cooperation within the mac and also the PHY layer. within the proposed protocol, a data frame is transmitted sequentially 2 times: Once from the transmitter and once from the helper. Since the receiver is able to catch both transmissions, inherently the protocol will support cooperative schemes within the PHY layer. They have a tendency to are planning to combine several PHY layer schemes with the cooperative mac to study the more enhancements we will gain by such a combination.we've got propose the Coop-MAC protocol for ad hoc networks. Then in this paper have a tendency to create a detailed introduction of the frame format, the relay selection criterion, and conjointly the operating methodology of the projected mac protocol. we've got a tendency to also analyze the influence of relay. Finally, we have a tendency to validate the performance of the Coop-MAC through simulation. Compared with the adaptatively rate theme, Coop-MAC can effectively improve the network throughput and reduce the average delay

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