STUDY AND COMPARISON OF MULTICHANNEL MAC PROTO-COL WITH DCA AND IEEE 802.11 PROTOCOLS IN ADHOC NET-WORK

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Abstract

Many of multichannel protocols are designed to share multiple channels and allow non interfering use of channels through single transceiver. The IEEE 802.11 standard allows for the use of multiple channels available at the physical layer, but its MAC protocol is designed only for a single channel. A single-channel MAC protocol does not work well in a multi-channel environment, because of the multi-channel hidden terminal problem. Our proposed protocol enables hosts to utilize multiple channels by switching channels dynamically, thus increasing network throughput while increasing network analysis time. The protocol requires only one transceiver per host, but solves the multi-channel hidden terminal problem using temporal synchronization. Our scheme improves network throughput significantly, especially when the network is highly congested. The simulation results show that our protocol successfully exploits multiple channels to achieve higher throughput than IEEE 802.11 and DCA protocol.

Keywords*: Ad hoc network, medium access control, multi-channel*

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1. INTRODUCTION

A medium access control (MAC) protocol for ad hoc wireless networks that utilizes multiple channels dynamically to improve performance. The IEEE 802.11 standard allows for the use of multiple channels available at the physical layer, but its MAC protocol is designed only for a single channel. A single-channel MAC protocol does not work well in a multi-channel environment, because of the multi-channel hidden terminal problem. MMAC protocol [1] enables hosts to utilize multiple channels by switching channels dynamically, thus increasing network throughput. The protocol requires only one transceiver per host, but solves the multi-channel hidden terminal problem using temporal synchronization. We present an innovative routing protocol that utilizes multiple channels simultaneously to improve the performance of multiple MAC protocol in ad-hoc network. Routing protocol in needed to send data from one device to another. Whenever the packet is to travel to its destination via several intermediate modes routing protocol is needed. Several well know routing protocols are

2. IEEE 802.11 DISTRIBUTED COORDINATION FUNCTION (DCF)

In IEEE 802.11 DCF, a node reserves the channel for data transmission by exchanging RTS/CTS messages with the target node. When a node wants to send packets to another node, it first sends an RTS (Ready to Send) packet to the destination. The receiver, on processing the RTS, replies by sending a CTS (Clear to Send) packet to the sender. RTS and CTS packets include the expected duration of time for which the channel will be in use. Other hosts that overhear these packets must defer their transmission for the duration specified in the packets. For this reason, each host maintains a variable called the Network Allocation Vector (NAV) that records the duration of time it must defer its transmission. This whole process is called Virtual Carrier Sensing, which allows the area around the sender and receiver to be reserved for communication, thus avoiding the hidden terminal problem [10]. Figure 1 illustrates the operation of IEEE 802.11 DCF. When node B is transmitting a packet to node C, node A overhears the RTS packet and sets its NAV until the end of ACK, and node D overhears the CTS packet and sets it's NAV until the end of ACK. After the transmission is completed, the stations wait for DIFS and then contend for the channel.

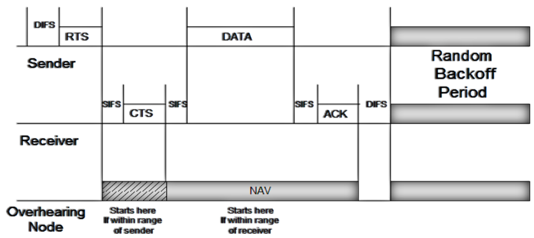

Figure 1 Operation of IEEE 802.11 DCF.

In this figure, node B is a hidden terminal to node D. If a node has a packet to send but observes the channel to be busy, it performs a random back off by choosing a back off counter no greater than an interval called the contention window. Each host maintains a variable cw, the contention window size, which is reset to a value CWmin when the node is initiated. Also, after each successful transmission, cw is reset to CWmin. After choosing a counter value, the node will wait until the channel becomes idle, and start decrementing the counter. The counter is decremented by one after each "time slot", as long as the channel is idle. If the channel becomes busy, the node will freeze the counter until the channel is free again. When the backoff counter reaches zero, the node will try to reserve the channel by sending an RTS to the target node. Since two nodes can pick the same backoff counter, the RTS packet may be lost because of collision.

Since the probability of collision gets higher as the number of nodes increases, a sender will interpret the absence of a CTS as a sign of congestion. In this case, the nodes will double its contention window to lower the probability of another collision. Before transmitting a packet, a node has to wait for a small duration of time even if the channel is idle. This is called interframe spacing. Four different intervals enable each packet to have different priority when contending for the channel. SIFS, PIFS, DIFS, and EIFS are the four interframe spacings, in order of increasing length. A node waits for a DIFS before transmitting an RTS, but waits for a SIFS before sending a CTS or an ACK. Thus, an ACK packet will win the channel when contending with RTS or DATA packets because the SIFS duration is smaller than a DIFS.

2.1. Multi-Channel Mac (Mmac) Protocol

In this section, we present MMAC protocol. Some assumptions are-

• *N* channels are available for use and all channels have the same bandwidth[1]. None of the channels overlap, so the packets transmitted on different channels do not interfere with each other. Hosts have prior knowledge of how many channels are available.

• Each host is equipped with a single half-duplex transceiver. So a host can either transmit or listen, but cannot do both simultaneously. Also, a host can listen or transmit on only one channel at a time. So when listening to one channel, it cannot carrier sense on other channels

• The transceiver is capable of switching its channel dynamically. The time elapsed for switching the channel is 224μs

• Nodes are synchronized, so that all nodes begin their beacon interval at the same time.

2.1.1 Channel negotiation and Data exchange in MMAC

Suppose that node A has packets for B and thus sends an ATIM packet to B during the ATIM window, with A's PCL [1] included in the packet. On receiving the ATIM request from A, B decides which channel to use during the beacon interval, based on its PCL and A's PCL. After selecting the channel, B sends an ATIM-ACK packet to A, specifying the channel it has chosen. When A receives the ATIM-ACK packet, A will see if it can also select the channel specified in the ATIM-ACK packet. If it can, it will send an ATIM-RES packet to B, with A's selected channel specified in the packet. If A cannot select the channel which B has chosen, it does not send an ATIM-RES packet to B. The process of channel negotiation and data exchange in MMAC is illustrated in Figure 1. During the ATIM window, A sends ATIM to B and B replies with ATIM-ACK indicating to use channel 1. This ATIM-ACK is overheard by C, so channel 1 will be in LOW state in C's PCL. When D sends ATIM to C, C selects channel 2. After the ATIM window, the two communications can take place simultaneously

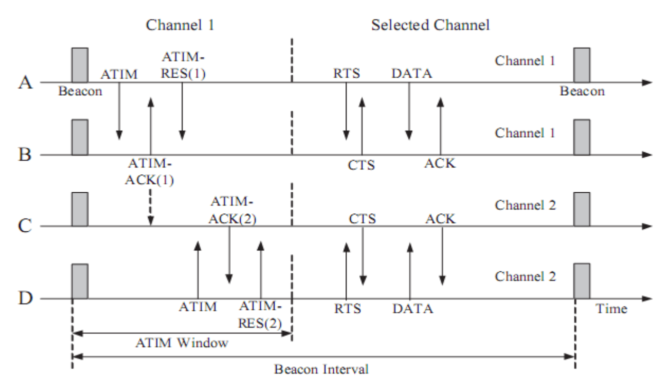

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Fig 2: Process of channel negotiation and data exchange in MMAC.

3 SIMULATION MODEL

For simulation we have used ns-2 [4] with CMU wireless extension [5] Bit rate for each channel is 2Mbps, transmission range of each node is approx 250 m and beacon interval is set to

100ms.Each source node generates and transmits CBR traffic. We assume channels. The parameter we vary number of nodes, and routing agent. Each simulation was performed for a duration of 40 seconds. Each data point in the result graphs is an average of 30 runs. Unless otherwise specified, we assume 3 channels. Also we assume packet size is 512 bytes, and ATIM windows are 20ms unless specified otherwise. The parameters we vary are: number of nodes in the network, the packet arrival rate of CBR traffic.

4 SIMULATION RESULTS

Simulation results are presented in the graphs, the curve labeled as “802.11” refer to original IEEE 802.11 single channel MAC, the curves labelled as “DCA” indicate the DCA protocol from [10], and the curves labelled as “MMAC” indicate multichannel MAC protocol. Figure 4 shows the aggregate throughput of different protocols as the network load increases. Graph show comparison between throughput and time. The network sizes are 10, 30 and 50 nodes in Figure 4 and 5 respectively. When network load is low, DCA and MMAC perform similarly. As network load draws near saturation, MMAC performs significantly better than IEEE 802.11, and also does better than DCA. Since there are 4 channels, DCA uses 1 channel for control packets and other 3 channels for data. By using this separate control channel, DCA achieves almost twice the throughput of IEEE 802.11. MMAC uses all 4 channels for data exchange, but cannot achieve 3 times as much throughput compared to IEEE 802.11 because of its overhead for channel negotiation. The overheads in MMAC are periodic beacon transmissions and ATIM packets. As the graphs show, MMAC performs 20%-30% better than DCA. The throughput improvement of MMAC over DCA may not be dramatic, but it is important that MMAC achieves this throughput using only a single transceiver per node. When network load is 10 all nodes attain their position and start sensing the signals in large area 1000*1000. Throughput is very high at initial network analysis time due to large communication gap between nodes , packets are collide while transmitting .hence throughput reduces at certain interval when packet reached to their respective destination node then again throughput increases. Due to packet drop and energy lost while transferring packets throughput start decreasing after certain network analysis.

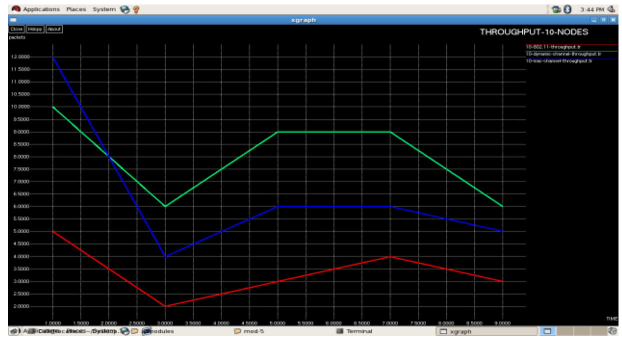

Figure 3 Comparison graph for Throughput vs. time for 10 nodes between 802.11, DCA and MMAC Protocol

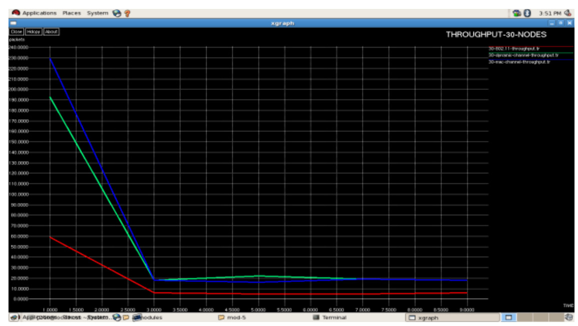

Figure 4 Comparison graph for Throughput vs. time for 30 nodes between 802.11, DCA and MMAC Protocol

Similarly when load increases then their chance of collusion reduces and throughput is high at initial time for MMAC than DCA, throughput decayed due to energy loss at certain time while transferring packets form one node to another.

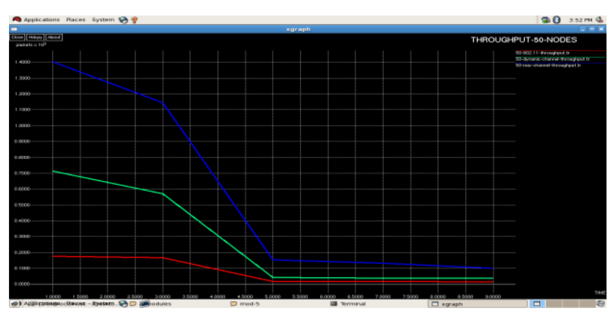

Figure 5 Comparison graph for Throughput vs. time for 10 nodes between 802.11, DCA and MMAC Protocol

Figure 6 shows the average packet delay of the protocols as the network load increases. The difference between IEEE 802.11 and other protocols in delay is due to the fact that with only one channel, a packet has to wait longer to use the channel when the network load is high. When comparing DCA and MAC, MMAC shows higher delay in the network scenario with 10 nodes. Then the delay of the two protocols becomes similar with 30 nodes, and MMAC out performs

Figure 6 Comparison graph for delay vs. time for 10 between 802.11, DCA nodes of MMAC protocol

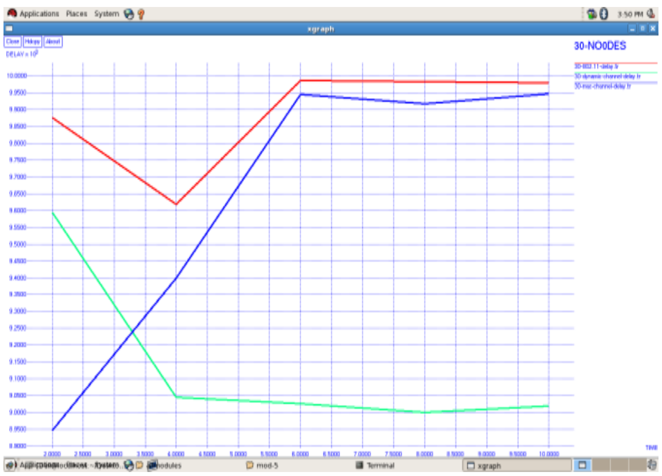

Figure 7 Comparison graph for delay vs. time for 30 between 802.1, DCA nodes of MMAC protocol

Figure 8 Comparison graph for delay vs. time for 50 between 802.11, DCA nodes of MMAC protocol

CONCLUSIONS

In this paper, we have presented a multi-channel MAC Protocol that utilizes multiple channels to improve throughput in wireless networks through AODV routing protocol. Simulation results shows that MMAC successfully exploits multiple channels to improve total network throughput over IEEE 802.11 single-channel. The performance of MMAC and DCA depends on the network situation, but as the simulation results show, MMAC performs better or at least comparable to DCA in most cases. It is important that MMAC achieves this performance using simpler hardware than DCA.

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