Energy Efficient MAC Layer Protocol for Mobile Ad-Hoc Networks

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Abstract

This paper presents energy efficient MAC protocol for ad-hoc network that provide low power operation with collision avoidance and improves channel utilization. This scheme reduces energy consumption without diminishing the capacity or connectivity of the network. It is observed that when sender send packet to receiver it simply broadcast the packet. All the nodes in the network receive the packet but only few of them forward it to receiver. In this scheme we select coordinator nodes from all the available nodes in network. Packets are transmitted through this coordinator node. Each node has to make decision whether it is participating in transmission or remains sleep. Thus the algorithm reduces the energy consumed by the non coordinator nodes in the network.

I. Introduction

Wireless networks have become increasingly popular in the computing industry since from 1970s. This is particularly true within the past decade which has seen wireless networks being adopted to enable mobility. There are currently two types of mobile wireless networks available. The first one is known as infrastructure network, i.e., the network with fixed and wired gateways. These networks contain a base stations through which all nodes are communicated. A mobile node within these networks connects to, and communicates with, the nearest base station which is within its communication radius. As the mobile travels out of range of one base station and into the range of another, a "handoff" occurs from the old base station to the new, and the mobile is able to continue communication seamlessly throughout the network. Typical applications of this type of network include office wireless local area networks (WLANs). The second type of mobile wireless network is known as infrastructure less network, commonly known as an Ad-Hoc network. This type of network has no fixed routers; all nodes are capable to move in arbitrary manner and can be connected dynamically with each other. Each node in the network acts as router to discover and maintains the route to the other nodes in network [3].

Mobile Ad Hoc networks are autonomously self organized networks without infrastructure support. Which are widely used in Military communication, automated battlefield, Search and Rescue operation, and Disaster recovery, Education, Sports and Robotics, Energy consumption is the major issue in the MANET since typical wireless devices are powered by small size batteries, whose replacement is difficult or even impossible in some applications like disaster recovery, battle field. Thus energy consumption is one of the good criteria for the MANET design.

Since there is no centralized infrastructure available in MANET, the routing mechanism has been incorporated by nodes. And since having dynamic nature of MANET, it is more difficult for each individual node to establish most suitable path from source to destination and for each source to destination, it has to keep track of the established route at regular time of interval. If any one of the nodes goes out of energy while the communicating the whole process will be interrupted and again it's require to establish the path for the specified source to destination. Thus regular route updating and route maintenance process consumes a lot of energy of the battery which is limited. Moreover, the traditional routing protocol of MANET is the major causes of high power consumption because of the traditional routing mechanism is based on minimum hop count i.e. while selecting a path from as source to destination, it selects a path which is having minimum number of intermediate nodes among all possible paths. As the distances between each pair of nodes get increased, the amount of transmission power also gets increased. And it is found that the more amount of energy is consumed while transmitting a data rather than receiving a data. So the power level of nodes are also getting affected the ease with which route is established between a pair of nodes. Apart from this issue, many traditional routing protocols are least concerned with the energy consumption of the nodes and few energy related parameters like energy consumed per packet, energy required per transmission, remaining battery power of the node etc. So in this paper we introduce power controlled energy efficient MAC protocol.

So the next section II will shade some lights on basic MAC layer IEEE 802.11 mechanism and it reveals why MAC protocol requires some more attention in energy consumption. Section III Includes related works done on this area. In section IV proposed 802.11 ad-hoc power saving mode. Section-V has simulation results and section-VI gives final conclusion.

II. OVERVIEW OF IEEE 802.11 DCF PROTOCOL

IEEE 802.11 DCF has two access methods: *basic access method* and *RTS/CTS* access method. The basic access method includes only DATA/ACK exchange, in which data packets are transmitted when channel access is available. ACK frames follow successful data packet receptions. The RTS/CTS mechanism is used to minimize the amount of time wasted when a collision occurs during transmission and to address the *Hidden Terminal* problem. In the RTS/CTS access method, when a sender node wants to send packets to another node called destination, it first sends an RTS (Request to Send) packet to the destination node and after sensing the medium to be idle for a so called DIFS interval. When the destination node receives an RTS (Request to Send) frame, it transmits a CTS (Clear to send) frame immediately after a so-called SIFS interval. The source node is allowed to transmit its data frame only when it receives the CTS correctly. If the CTS are not received by the source node, it assumes that a collision has occurred and an RTS retransmitted. After the data frame is received by the destination station, an acknowledgment frame is sent back to the source verifying successful data reception.

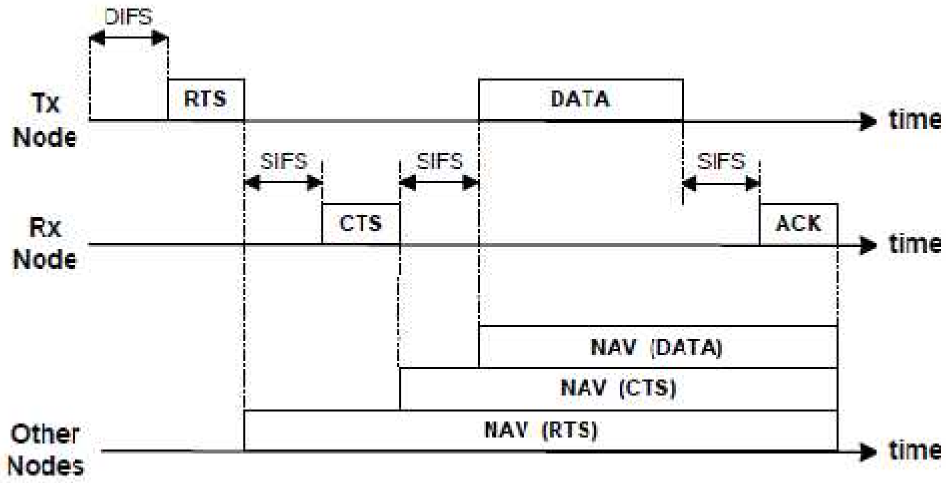

Fig. 1: IEEE 802.11 DCF operation [5]

The use of the RTS/CTS method helps to minimize the collisions and the collisions caused by hidden terminals. The successful exchange of RTS and CTS, reserves the transmission medium for receiver and sender and guaranteeing for undisturbed transmission for longer data frame. Clearly, if a collision occurs with two or more small RTS frames, the time loss is smaller than the collision of long data frames. On the other hand, RTS/CTS decrease the efficiency because it required transmitting two additional frames without any payload. Furthermore, the IEEE 802.11 standard defines a parameter *RTS-Threshold* that indicates the data length for the data frames should be sent without RTS/CTS. The *RTS-Threshold* parameter is not fixed in the standard and has to be set separately by each station. A collision occurs when two or more stations within the transmission range of each other transmit simultaneously in the same time slot.

III. Related Work

A Power Control MAC (PCM) protocol allows per-packet selection of transmits power [4]. In PCM, RTS/CTS packets are transmitted with a max power level, *Pmax*. But for data packets, they are transmitted with a lower power level. In order to avoid a potential collision caused by the reduced carrier sensing zone, during the DATA packet transmission PCM periodically increases the transmission power to *pmax*. ACK packets are transmitted with the minimum required power to reach the source node. Figure 5 shows the power level used in PCM. By periodically increasing the power level for data transmission, PCM effectively reduces the amount of possible collisions. This way, retransmission is avoided as much as possible, and correspondingly, the goal of energy savings is achieved. Results show that PCM can achieve a throughput comparable to the IEEE 802.11 but with less energy consumption.

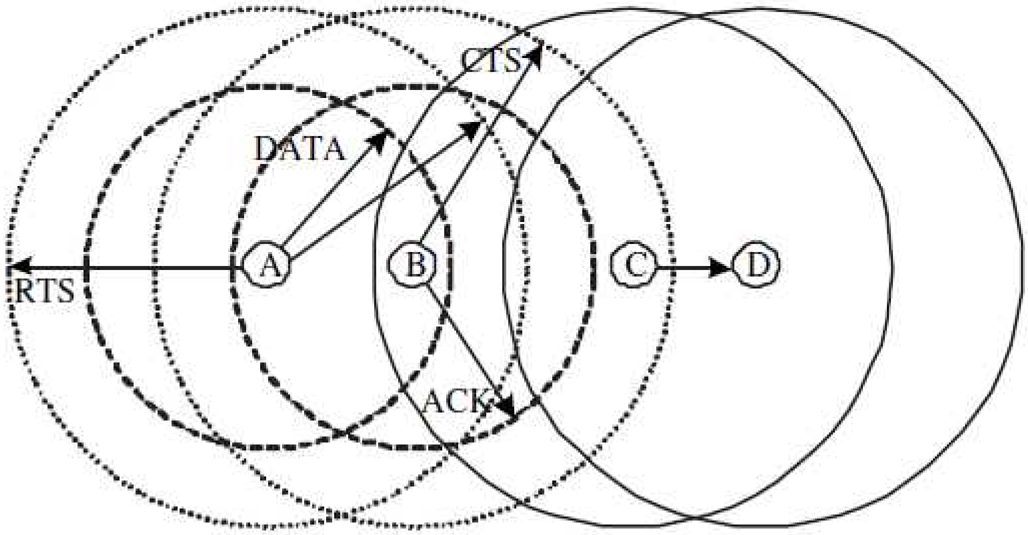

Fig. 2: PCM Scheme: Data packets are transmitted with a periodically increased power level [4]

IV. 802.11 ad-hoc Power Saving Mode

In 802.11 ad hoc power-saving Mode we use periodic *beacons packet* to synchronize nodes in the network. Beacon packets have timestamps that synchronize node's clocks in network. A beacon timestamp period starts with an ad hoc traffic indication message window (*ATIM window*), during which all nodes are in listening mode, and pending traffic transmissions are advertised. A node that receives and acknowledges an advertisement for unicast or broadcast traffic directed to it must stay on for the rest of the beacon period. Otherwise, it can turn itself off at the end of the ATIM window, until the beginning of the next beacon period. After the ATIM window, advertised traffic is transmitted. Since traffic cannot be transmitted during the ATIM window, the available channel capacity is reduced. When the 802.11 MAC layer is asked to send a packet, it may or may not be able to send it immediately, depending on which ATIM's have been sent and acknowledged in the immediately preceding or current, ATIM window. If the packet arrives at the MAC during the ATIM window, or if the advertisement for the packet has not been acknowledged, it needs to be buffered. In our implementation, we buffer packets for two beacon periods. Packets that have not been transmitted after two beacon periods are dropped. The beacon period and ATIM window size greatly affect routing performance. While using a small ATIM window may improve energy savings, there may not be enough time for all buffered packets to be advertised. Using an ATIM window that is too large not only decreases available channel utilization, it may also not leave enough room between the end of the ATIM window and the beginning of the next beacon period to transmit all advertised traffic. We have experimentally determined that a beacon period of 200 ms and an ATIM window size of 40 ms result in good throughput and low loss rate. Aside from decreased channel capacity, 802.11 power saving mode (without Span) also suffers from long packet delivery latency: for each hop that a packet traverses, the packet is expected to be delayed for half a beacon period.

V. Simulation and Results

Simulation Implementation starts with developing Network scenario for 10 nodes in NS-2. To develop network scenario TCL script is designed for 10 nodes. The network traffic is bided to the node. The performance is measured through the simulation in NS-2. Figure 3 shows the network scenario in NAM (network animator). Figure 4 shows Results of the 802.11 ad hoc power-saving Modes the graph shows the total packet transmits, receives and the total number of packets dropped.

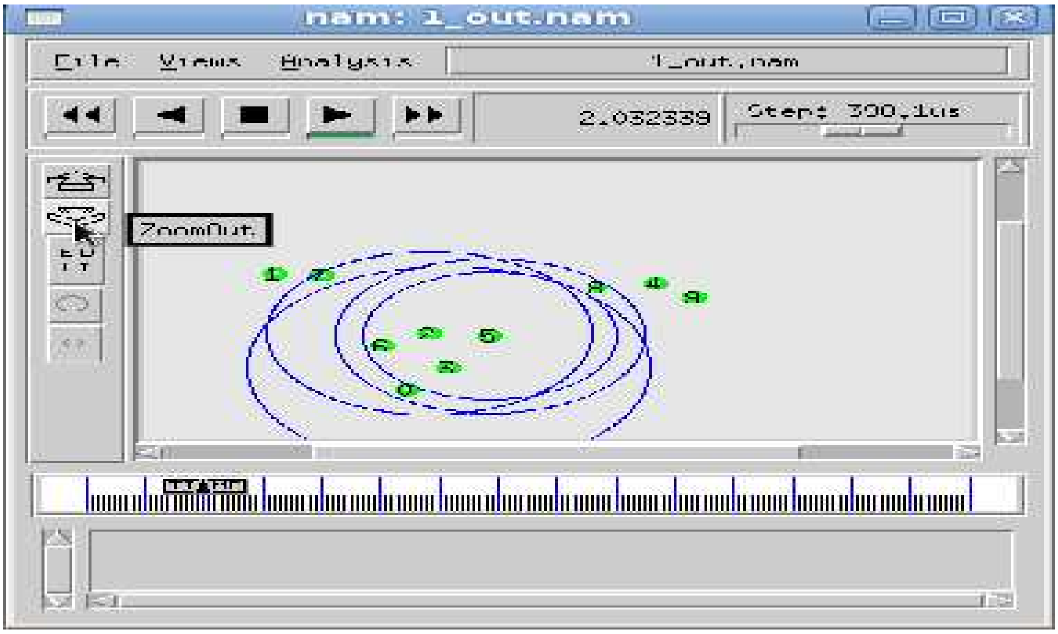

Fig.3: Nodes Scenario.

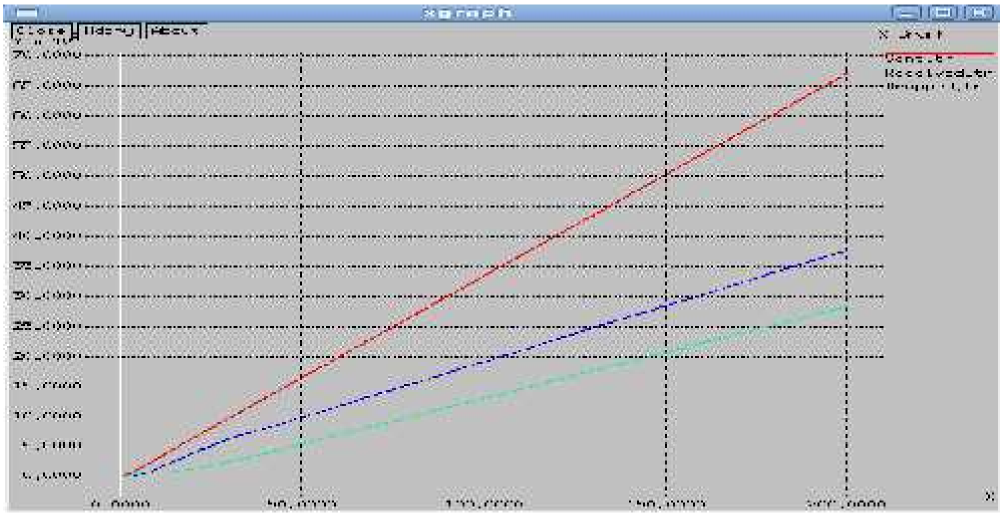

Fig.4: Simulation Results

VI. Conclusion.

The performance of the 802.11 ad hoc power-saving Mode reduces total number of dropped packets thus the energy consumption is reduced. The beacon packet defines the timestamp and ATIM window is smaller than the beacon periods so the channel utilization will improve and packets are transmitted through the nodes during ATIM window period so the energy consumption is reduced in overall network.

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