An Energy Efficient MAC Protocol for Wireless Ad-Hoc Networks

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***Abstract*--Wireless networks become an integral part of the modern communication infrastructure, Energy-efficiency is an important design consideration due to the characteristics of wireless ad hoc network, particularly for mobile users with limited power supply. Medium access control (MAC) protocols play an important role in providing a fair and efficient allocation of the available bandwidth. A new energy-efficient MAC protocol (e-MAC) is proposed in this paper. In the proposed scheme, the packet transmission is adjusted based on network load. Thus nodes need to wake up only at the assigned time and in remaining time they enter into sleep state. There by reduces the energy consumption. Thus proposed scheme achieves high throughput, low packet transmission delay.**

Index Terms—Medium access control protocol, ad-hoc networks, energy efficiency, IEEE 802.11

1. INTRODUCTION

A wireless ad hoc network is a collection of two or more nodes, which can be mobiles. These nodes are equipped with wireless communication and networking capabilities. These nodes are communicated without the aid of a planned infrastructure or any central administration as shown in Figure 1.1. Energy efficiency is an important design consideration in wireless adhoc network, particularly for battery powered devices such as smartphones. Because there is no pre-existing infrastructure in adhoc network, so the mobile nodes must act as routers and should be participating in forwarding process. Therefore, network traffic load in mobile adhoc networks are higher than wireless networks with APs and BSs. Thus, effective mobile communication requires establishing energy efficient, high throughput, low latency wireless adhoc network. The radio interface of mobile devices is the main source of energy consumption [3].

In a smartphones the WiFi radio consumes more than 70% of total energy when the screen is off [4]. When the screen is on and off energy consumption is reduced to 44.5% and 50% respectively[6].

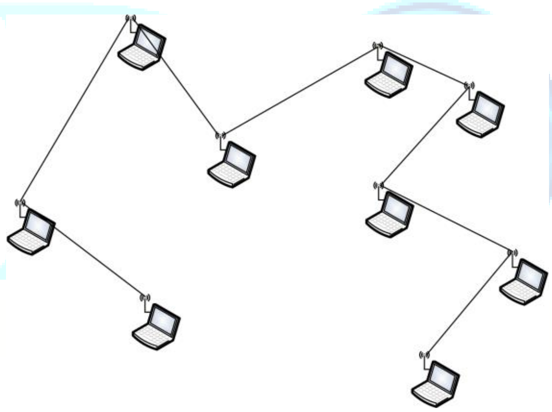

Figure 1.1: A wireless ad hoc network

A radio interface has four modes: transmit, receive, idle and sleep In transmit mode it has the maximum power consumption and in sleep mode has low power consumption. A node needs to sense the transmission medium in the idle mode and consume same amount of energy as in the receive mode. For instance, a *Cisco Aironet 350 series*WLAN adapter [6] consumes 2.25W, 1.25W, 1.25W, and .075W in the transmit, receive, idle and sleep modes respectively. So, we can clearly say that a significant amount of energy is consumed even in the idle mode.

This occurs in the CSMA/CA1 mechanism in IEEE 802.11 [7], in which each node has to continually sense the channel in the network. In order to conserve energy, power saving mechanisms [7]–[10] allow a node to enter in sleep mode by powering off its radio interface when the node is not involved in transmission.

Media access control protocol is a data communication protocol. It performs several functions, such as addressing, channel access control mechanisms and also it directly control the operation of radio interfaces. Mac is a sublayer of datalink layer determines how the network nodes share the transmission medium, Therefore Mac plays an important role in achieving high throughput, low latency and energy efficiency in wireless adhoc networks. Existing MAC protocol categorized into contention free and contention based methods shown in fig 1.2. In contention based scheme, schedule is predetermined, so that each node knows when to transmit the packet without any contention, which includes time-division, polling and token based MAC protocols. Contention based method suffer from synchronization and adaptability problems.

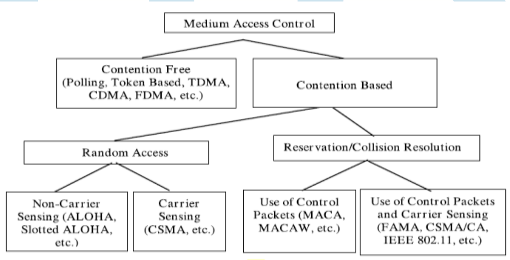

fig 1.2. Classification of MAC protocols

In contention based method MAC node dynamically choose the path to access the path. Contention based methods are not suitable in high data rate network. When data traffic is high there is an increased chance of transmission collisions. The transmitting nodes cannot detect collisions quickly. Only way to detect collisions is by the use of acknowledgement mechanisms. Whenever a transmission collision happens, the radio bandwidth and the energy for transmitting and receiving a packet are wasted. Thus an efficient MAC scheme is proposed in this paper. The main purpose of the proposed energy efficient MAC protocol is to reduce transmission collision, packet delay and to improve network throughput for wireless network.

Using a temporary node, named as head node, which act as a coordinator responsible for scheduling the active and sleep mode of radio interfaces. Thus decreases MAC overhead and collisions. In which nodes stay awake only at the scheduling time, which reduces energy consumption. The proposed scheme has shorter packet transmission delay, higher throughput and lower energy consumption.

The remainder of the paper is organized as follows. Section 2 contain brief description about previous works. In section 3, we describe the proposed e-Mac protocol. Section 4 presents numerical analysis to evaluate proposed protocol. Finally conclusion and future works are given in section 5.

2. RELATED WORKS

In this section, we provide description about existing power saving MAC mechanisms for ad hoc network.

In IEEE 802.11 power saving mode (PSM) is based on Ad hoc traffic indication messages (ATIMs). Nodes use ATIMs to notify other nodes to prepare to receive data. All nodes have to wake up periodically to listen for ATIMs and check whether they have packets to receive [11].

All nodes in the network can transmitted an ATIM, received an ATIM, neither transmitted nor received, or both transmitted and received. In Adhoc PSM [12,13], time is divided into beacon intervals and each beacon interval starts with an ATIM window that are used to synchronize the nodes. During this time period all nodes must stay awake and no stations are allowed to power down their wireless interface. The nodes use ATIM windows to announce the status of the packets ready for transmission. Nodes that transmit ATIM frames do not sleep because this indicates intent to transmit buffered traffic. Nodes to which an ATIM is addressed must also keep awake so they can receive data packets from the ATIM sender. A node that both transmits and receives of course needs to be active. Thus, only those nodes that neither transmit nor receive an ATIM can go to sleep after the ATIM window [11]. The ATIM-ACK packets are used as an acknowledgment mechanism for ATIM frames, which send during the same beacon interval transmitted from the destination.

A fixed ATIM window sizes can affect the performance of PSM, it decreases the performance in terms of throughput and energy consumption. If the ATIM window size is too small, nodes do not have enough time to advertise the buffered packets. On the other hand .ATIM size is too large, transmission time is reduced and increases the energy consumption, because all nodes have to stay awake during the ATIM interval. PSM was developed for single-hop networks. However, ad hoc networks are usually multi-hop networks, and thus PSM is not an ideal solution. Moreover, PSM also suffers from long packet delivery latency.

The dynamic power saving mechanism (DPSM) dynamically adjust the window size based on the network traffic load to reduce energy consumption [10].In the DPSM each node dynamically choose the ATIM window size based on network load. The TMMAC [14], time is partitioned into beacon interval has an ATIM window, each window used to advertise the status of packet ready for transmission. The window size is dynamically adjust based on the network condition, thus improve both efficiency and network throughput. Each node exchanges their control packets in order to reserve the transmission slot.

An asynchronous power saving MAC is proposed for multihop ad hoc networks in [15].In which each node has its own clock and in each beacon interval either stays awake for the whole beacon interval and transmits a beacon frame or follows the PSM mode of IEEE 802.11.This scheme introduce a new algorithm called quorum, this will ensure that the beacon of a node will be heard by any other node at least twice in a given interval of N beacons. Each beacon frame contain clock and wake up pattern of the sender node, so that other nodes to become aware of nodes wake up time, this will ensure successful delivery of packets.

In [16], a power saving mechanism is proposed based on the IEEE 802.11 RTS/CTS2 dialogue. Nodes that are neither transmitting nor receiving a packet switch off their wireless interfaces after overhearing RTS/CTS packets. In [17], all the RTS/CTS packet exchanges are performed over the signaling channel and data packets are transmitted over a different channel, which allows nodes to independently decide whether to stay awake or power off after overhearing the RTS/CTS packets. The PSM in network with access point is similar to that in an ad hoc network. Time is dived into beacon interval, which is used to broadcast a Traffic Indication Message (TIM) to a node to announce status of a packet ready for transmission in the AP. The nodes that have packets ready for them in the AP stay awake during the rest of beacon interval and poll the AP to receive the packets. Nodes that have packets ready for transmission to the AP also stay awake and send their packets to the AP during the beacon interval [8].

When there is only one AP in the network ,the power saving MAC protocols for networks with AP provide high performance and low energy consumption. However, in wireless local area networks, there are several APs usually located in the same area and have to contend with each other to access the shared channel, which degrade the network throughput and increases the energy consumption.

This paper, propose a new energy efficient mac protocol for fully connected wireless ad hoc network. The proposed protocol adapts to the network conditions. Thus it provide high throughput and low packet transmission delay.

3. PROPOSED SYSTEM

Consider a single-channel fully connected wireless network with N nodes. Where all nodes can hear transmissions from each other. Time is divided into beacon intervals of constant duration and all nodes are synchronized in time. By using a distributed beacon transmission mechanism, as in the IEEE 802.11 power saving, the synchronization can be achieved mechanism [8].

Each beacon interval consists of three different periods: announcement period, contention-free period, and contention period. A temporary coordinator node called head node, which dynamically adjusted the duration of time periods based on network load. Rather than selecting a random node as coordinator, selection is based on the data transfer rate of individual nodes. A node with minimum data transfer rate is selected as coordinator. A demand table is used to record the nodes request. The head node monitors the traffic and records it in demand table. During beginning of announcement period, head node advertises transmission schedule based on network load. The scheduling packets contain the following information: duration of frame, starting time of next beacon interval and the selected as the next head node

In Contention-free periods, nodes that are scheduled for transmitting/receiving packets wake up at the assigned time to transmit/receive packets and the head node stays awake. nodes with realtime traffic put their call status (on or off) in the header of the transmitted packets, and the sender nodes with non-realtime traffic put the number of the remaining packets ready for transmission in the header of their data packets. The head node uses the information to generate/update the demand table. In contention free periods transmission of packets is collision free , the packet may be corrupted by short-term channel fading. Therefore, ACK packets must be send by non-real time traffic. In contrast, realtime packets not transmitted before a deadline, it will be useless. Thus, no ACK packet is transmitted by the receiver for realtime packets.

Contention periods: In the contention periods, nodes (that have packets ready for transmission but were neither scheduled for transmission nor included in the pending traffic list transmitted by the head node in the previous announcement period) stay awake. It using a CSMA MAC protocol to submit a request. Once a contending node’s back-off counter reaches zero, it transmits an RTS packet to the head node. The RTS packet of a node with realtime traffic includes information of the maximum tolerable delay, maximum tolerable packet loss rate, the sender node ID, and the destination node ID. The RTS packet of a node with non-realtime traffic contains the number of packets that are ready for transmission at the sender, the sender node ID, and the receiver node ID. Head node schedule the packets based on the demands.

The proposed scheme has the following features: The transmission nodes stay awake at the beginning of announcement period and then enter into sleep and wake up at the assigned time to transmit receive packets without contention. The contention and transmission collision overhead is small and the workload is shared among all the nodes in the network. There for energy consumption can be reduced greatly.

4. NUMERICAL ANALYSIS

The simulation will involve around 10 nodes and the data transfer rate changes periodically. For a while the number of nodes involved in data transfer is set to a minimum and then suddenly a large number of nodes involves in data transfer. By using the proposed scheme we can render a drastic change in energy and throughput. The comparison between existing and proposed scheme will look, as shown in fig 4.1.In Fig 4.2 demonstrates average delay and drop of packets of existing and proposed scheme.

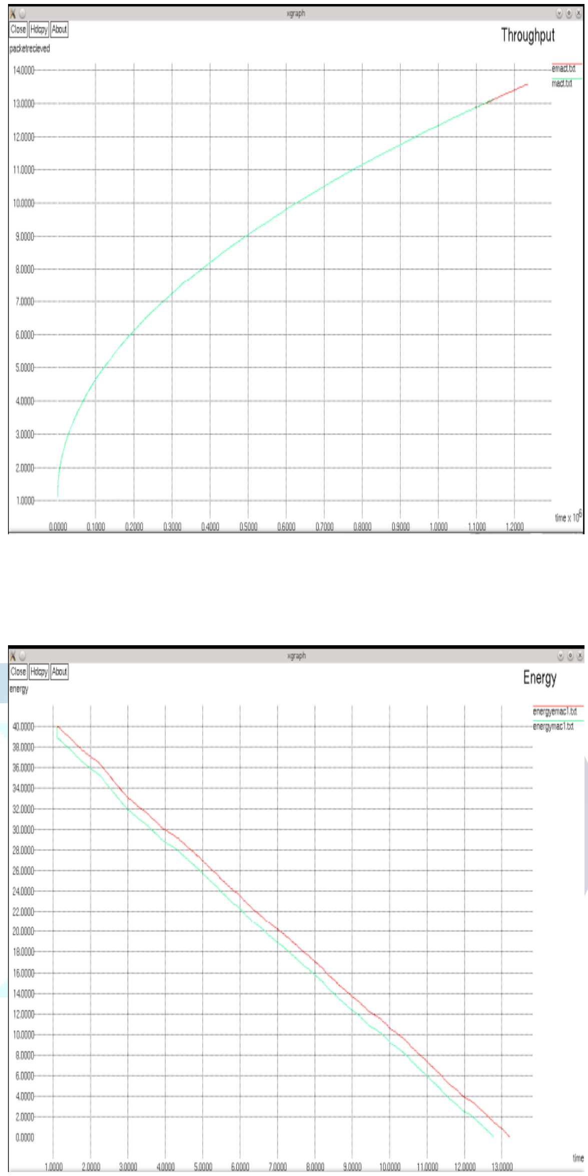

fig 4.1. Aggregate throughput and energy consumption of existing and proposed scheme

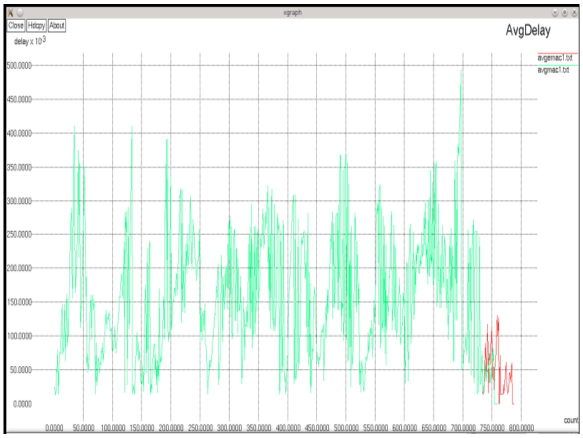

Fig 4.2. Average delay and drop of existing and proposed scheme

5. CONCLUSION AND FUTURE WORK

In this paper, proposed a new energy efficient mac protocol for fully connected wireless ad hoc network. The purpose of the paper is to reduce energy consumption without affecting the network performance. In the proposed protocol, a temporary coordinator adjusts the transmission based on network load. Thus nodes need to wake up only at the assigned time and in remaining time they enter into sleep state. There by reduces the energy consumption and increases throughput.

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